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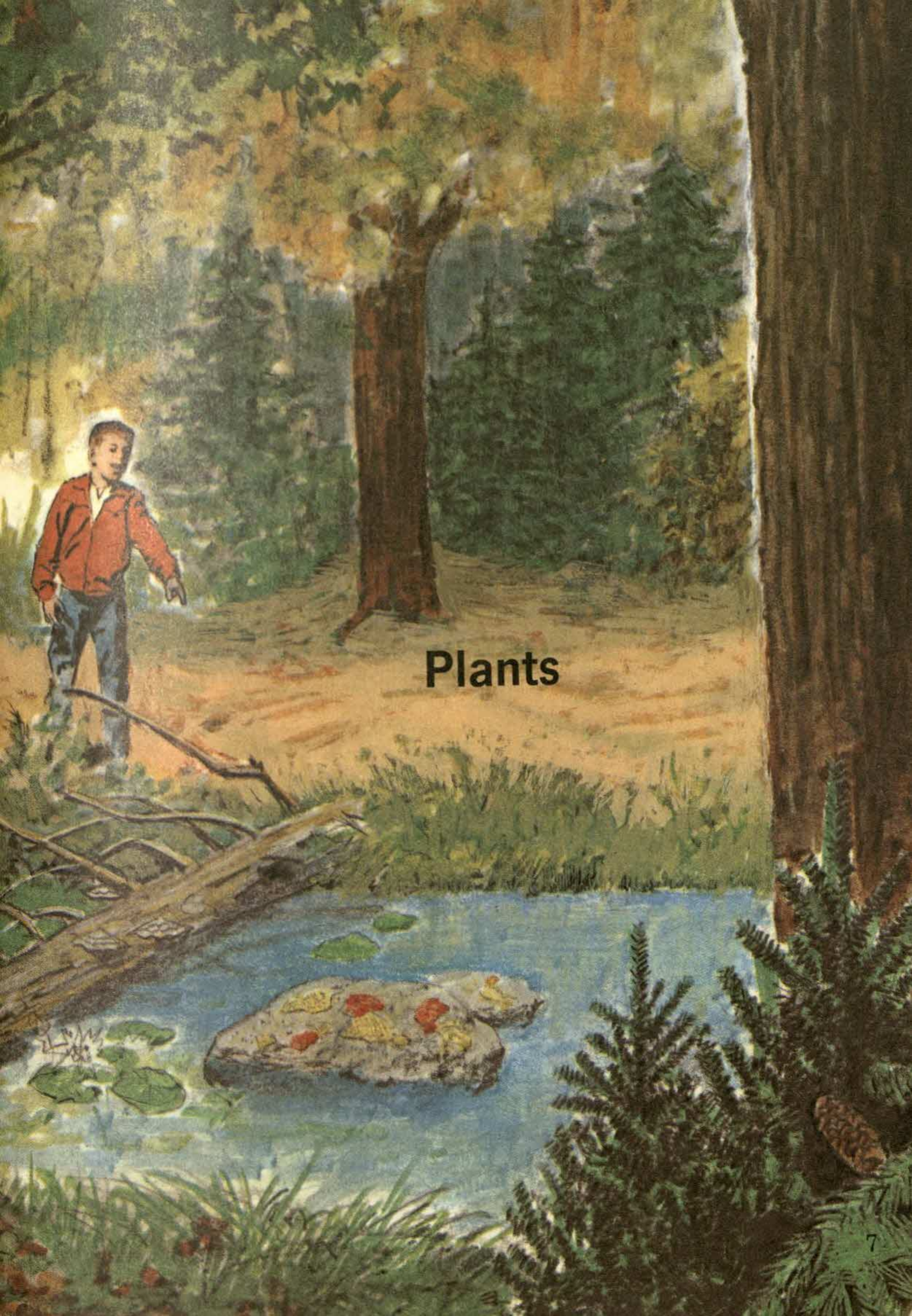


Plants

Look at the picture. Which things are alive?

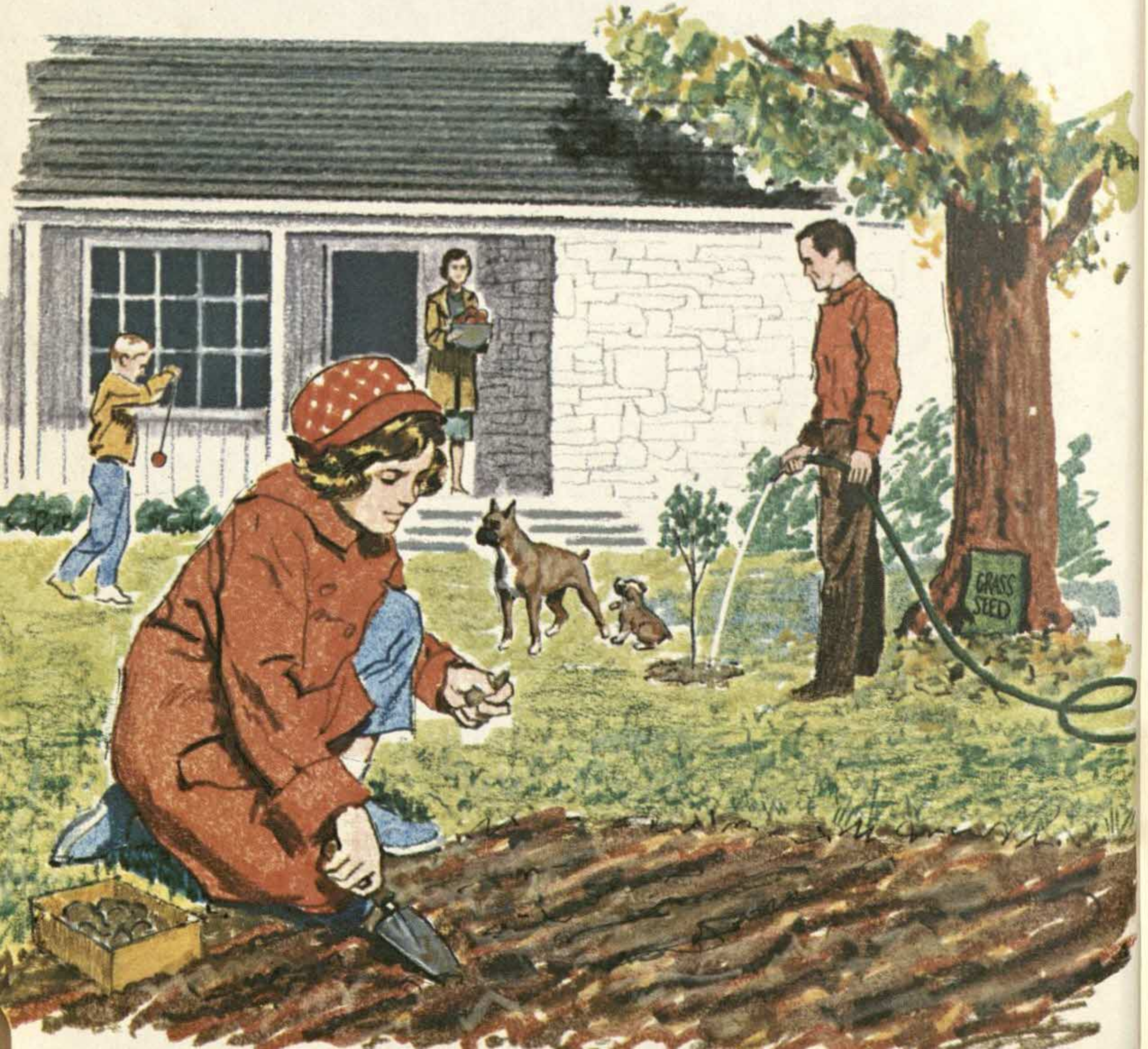
How do you know?

Is a plant alive?

How can you tell?

How are plants and animals alike?

How are they different?



Seeds

Most of the plants you know come from seeds. There are many different kinds of seeds.

Let's look inside a seed.

First look carefully at a lima bean seed.

DESCRIBE

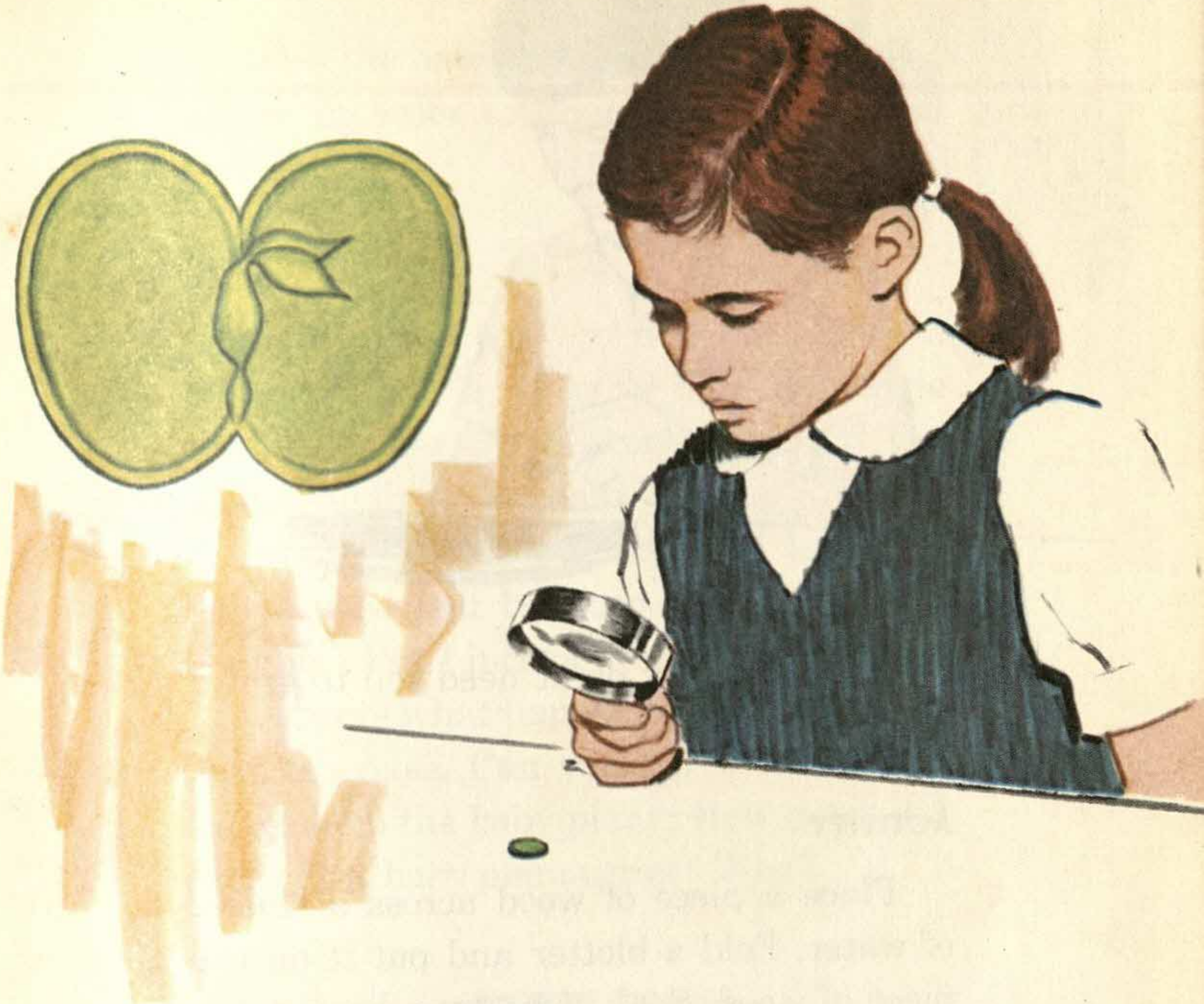
Can you find a scar on the seed?

Where do you think it came from?

Now soak your lima bean seed in water overnight.

OBSERVE AND DESCRIBE

Look at the lima bean seed.
What happened to it during the night?
How did the water get inside?



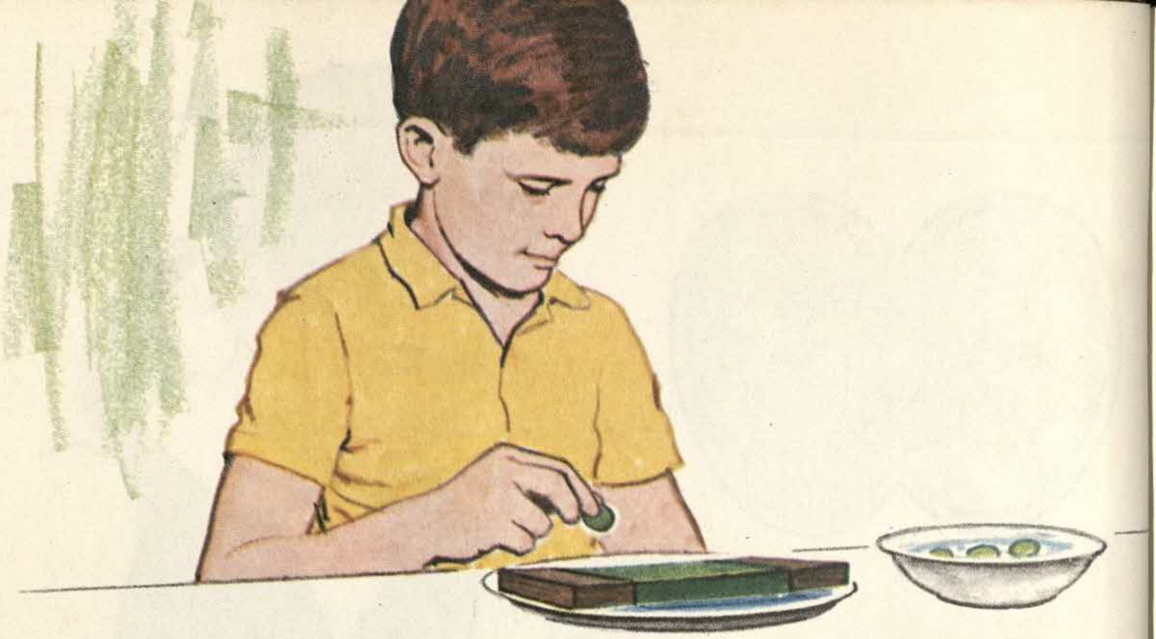
ACTIVITY

Take a pin and carefully peel the cover from the seed. How does this cover help the seed?

Open your seed. It has two large parts called seed leaves. Look closely. Can you see a baby plant inside?

Use a magnifying glass. Find the baby leaves, the stem, and the root.

Do all seeds have two halves and a baby plant?



Does the baby plant need soil to grow? Let's find out.

ACTIVITY

Place a piece of wood across a saucer of water. Fold a blotter and put it on the piece of wood. Soak some lima bean seeds and place them on the blotter.

Look at your seeds every day, and draw a picture of what you see.

What happens to the seed leaves as the baby plants grow bigger?

Where do the baby plants get their food?

How long will these plants grow?

Place some of the baby plants in soil.

How long do these plants grow?

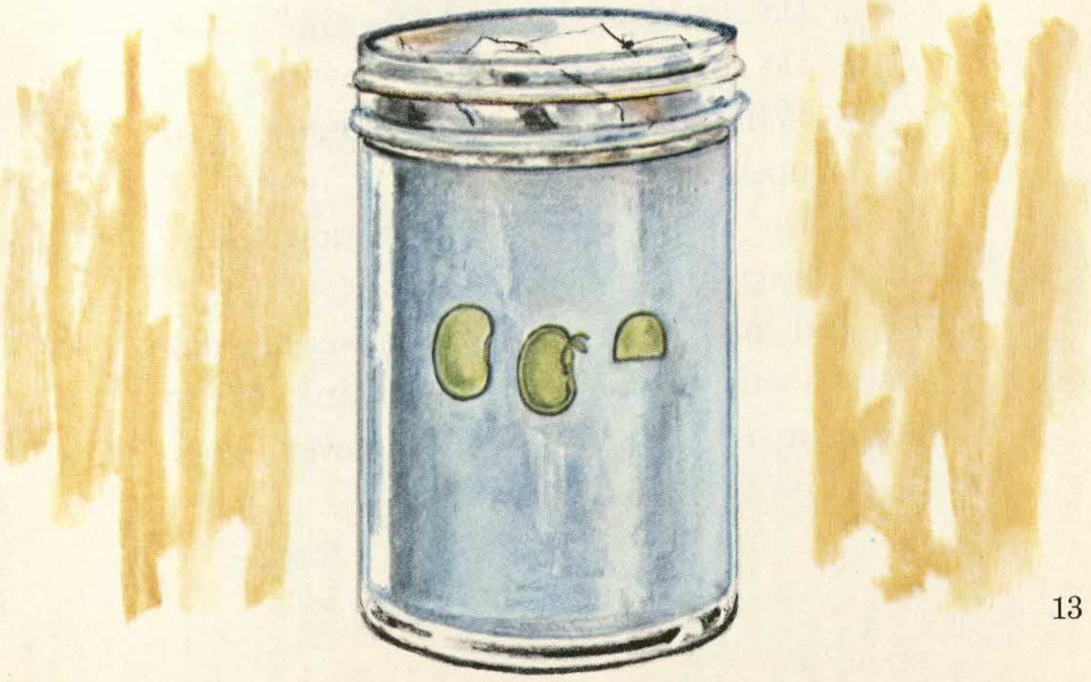
Does the baby plant need all of its seed leaves in order to grow? How would you find out?

OBSERVE

Here is one way to find out. Place a blotter inside a glass or jar. Put some crushed paper in the center to hold the blotter against the glass.

Put a whole seed, one seed leaf, and half a seed leaf between the blotter and the glass. Put 1 inch of water into the glass.

Observe what happens each day for the next ten days. Can you tell how the seed leaves help the baby plant? How much did each of the baby plants grow? Why?



Here are some more questions about seeds. Can you make up experiments to answer them?

1. Do some seeds grow faster than others?
2. If a seed is frozen will it grow?
3. Will a boiled seed grow?
4. Do seeds need air to grow?
5. Do seeds need water to grow?
6. Do seeds need light to grow?
7. What happens if you plant a seed upside down?
8. Do roots always grow down and stems always grow up?

You may have some questions of your own about seeds. Can you think of an experiment to help you answer your questions?

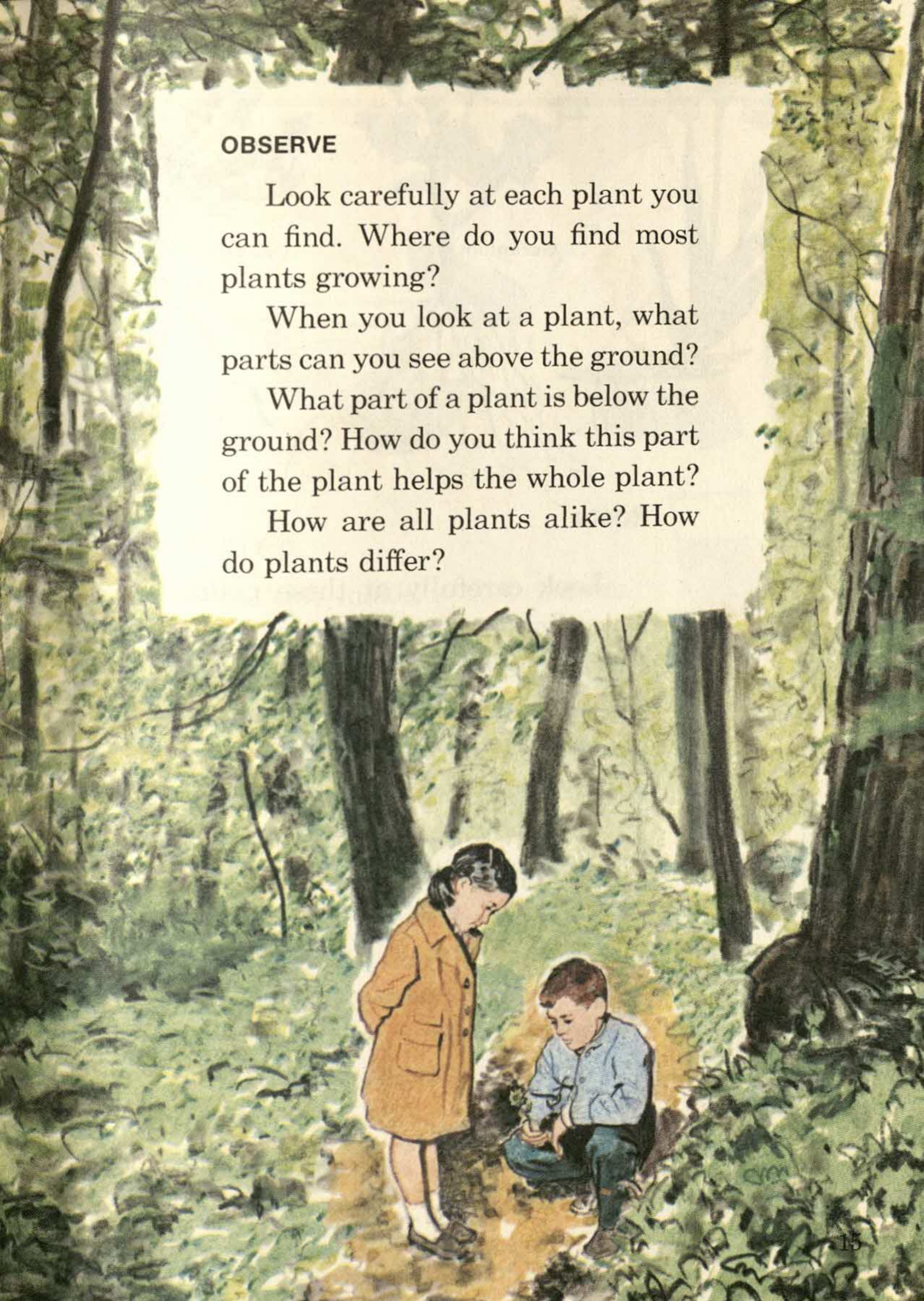
OBSERVE

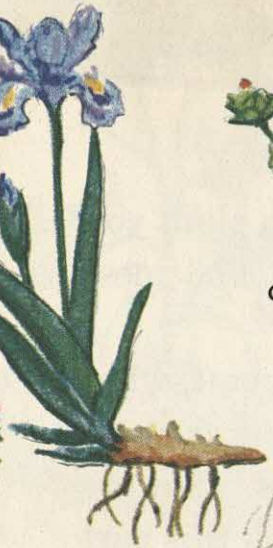
Look carefully at each plant you can find. Where do you find most plants growing?

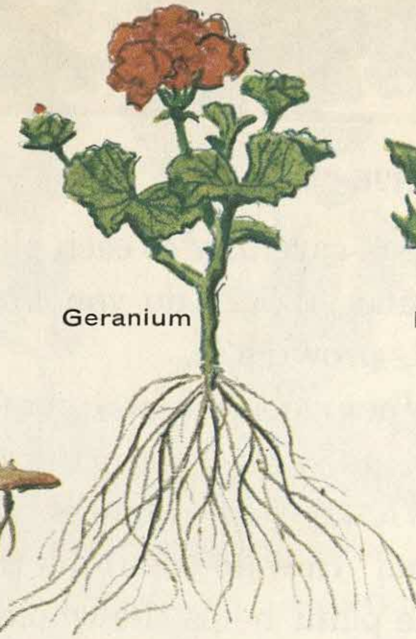
When you look at a plant, what parts can you see above the ground?

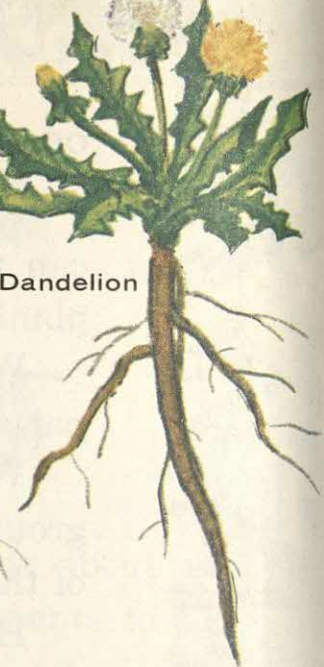
What part of a plant is below the ground? How do you think this part of the plant helps the whole plant?

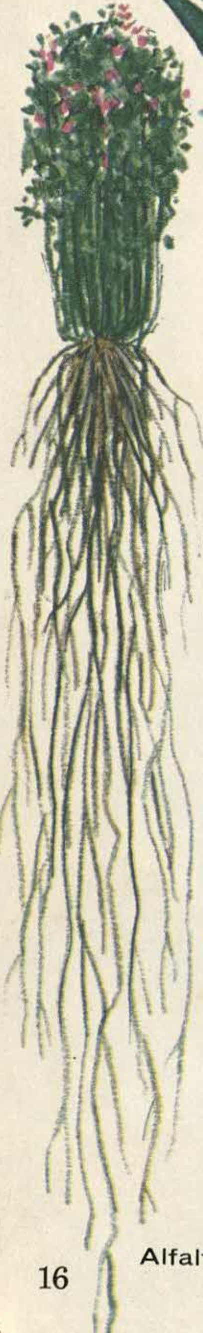
How are all plants alike? How do plants differ?











Roots

Look carefully at these plants. Point to the roots, the stems, the leaves, the flowers.

What part of the plant do you generally see? Describe the different roots.

The dandelion has a taproot. The geranium has roots that spread out in the soil. We use some taproots for food.

Can you name some foods that come from roots?

How do roots help plants?

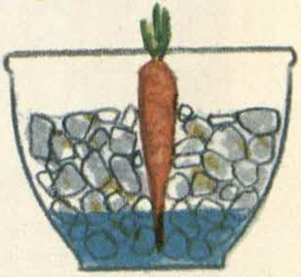
ACTIVITY

You can make a root garden. Take a beet, a carrot, a turnip, a sweet potato, or a parsnip. These are all taproots.

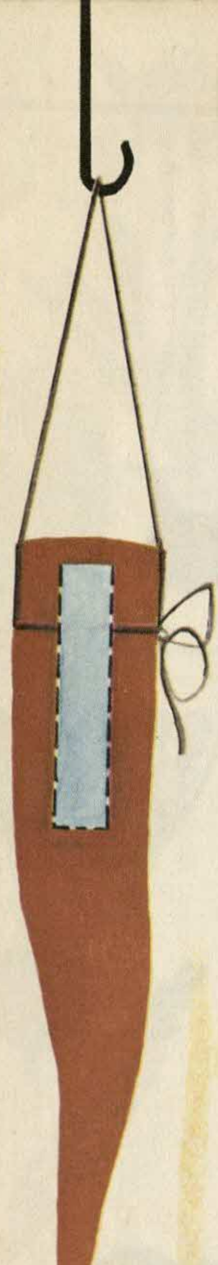
Fill a glass dish with gravel. Place the root in the gravel carefully. Pour in water so that the end of the root is covered. Keep the water at this level.

Put your garden in a sunny warm place and watch it grow. Measure each plant every day. Keep a daily record of your garden.

What would happen if there were no water?

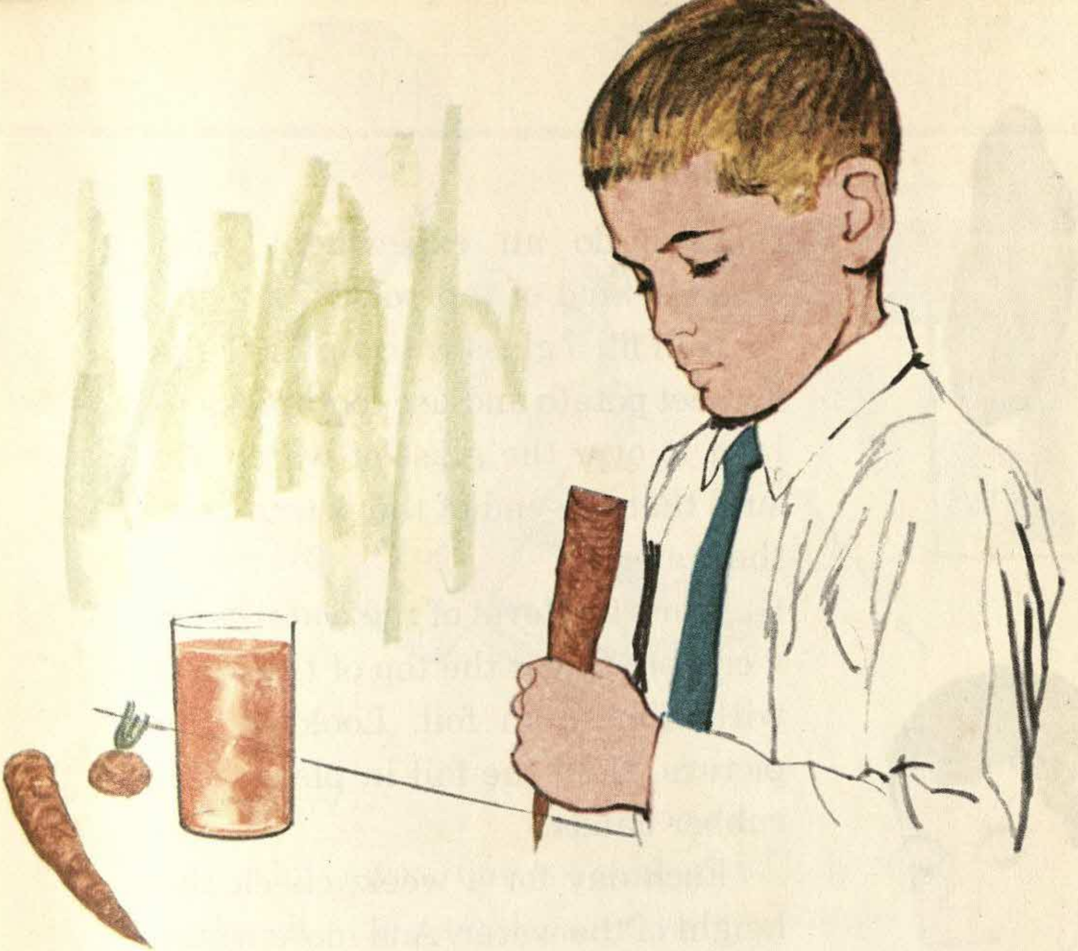


ACTIVITY



Scoop the center out of a large carrot. Hang the carrot up by a string. Fill the hole with water. Keep a daily record of what happens.

Cut an inch-long piece off the top of a carrot. Place this top in a flat dish filled with water. Leave the carrot hanging this way for several days. What happens?

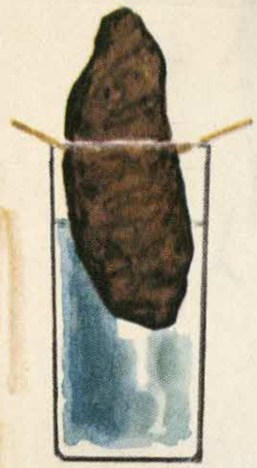


ACTIVITY

The part of the carrot which we eat is the taproot. The taproot takes in water. You can see how water moves through a taproot. Color some water red so that you will be able to see it better. Put a carrot in the red water for 3 hours or more. Cut the top off the carrot. What do you see?

Cut the rest of the carrot lengthwise. Can you tell where the water has gone?

Why did you have to color the water?



EXPERIMENT

Let's do an experiment with another kind of taproot.

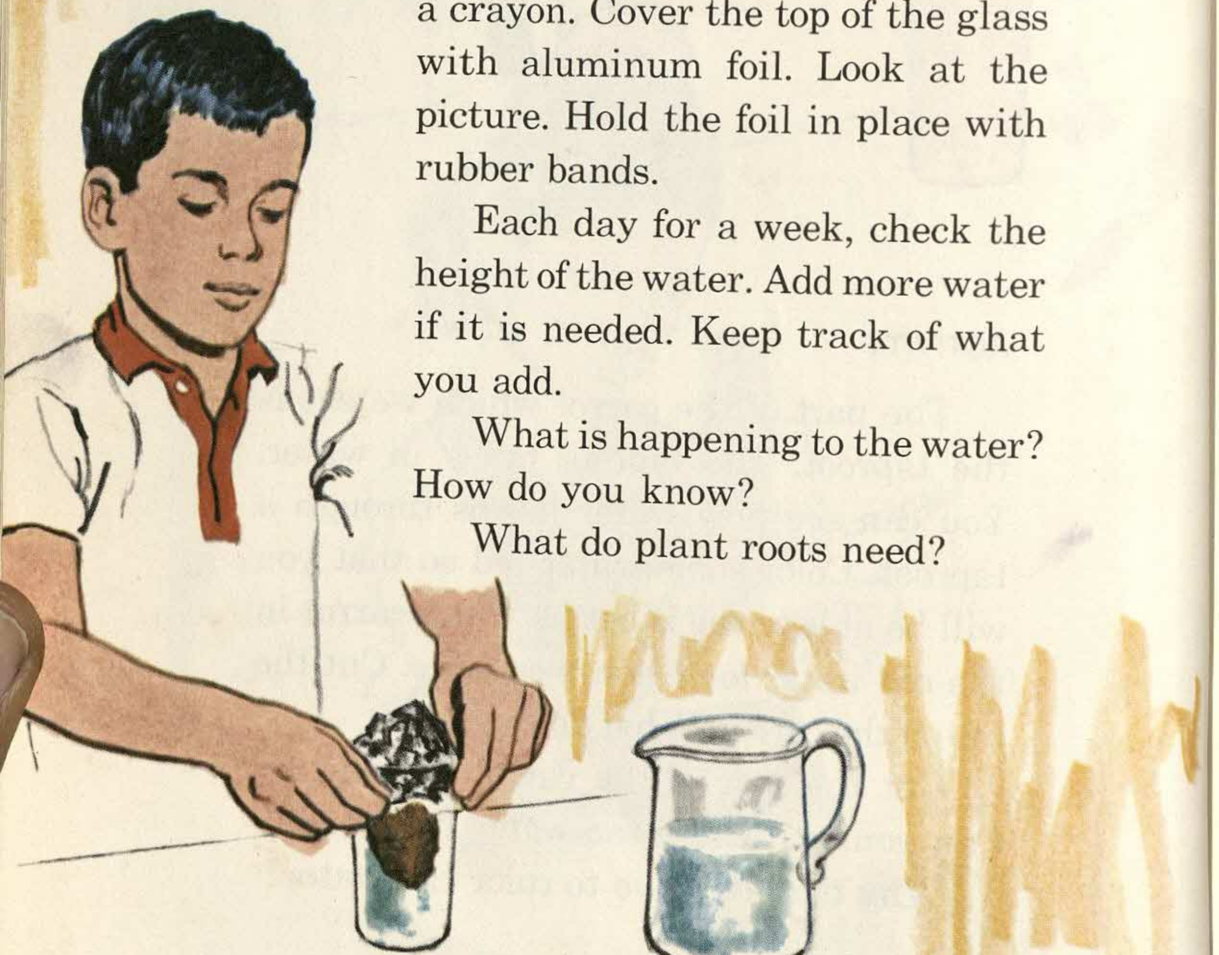
Half fill a glass with water. Take a sweet potato and use toothpicks to hold it over the glass of water. Be sure that the end of the potato is in the water.

Mark the level of the water with a crayon. Cover the top of the glass with aluminum foil. Look at the picture. Hold the foil in place with rubber bands.

Each day for a week, check the height of the water. Add more water if it is needed. Keep track of what you add.

What is happening to the water? How do you know?

What do plant roots need?



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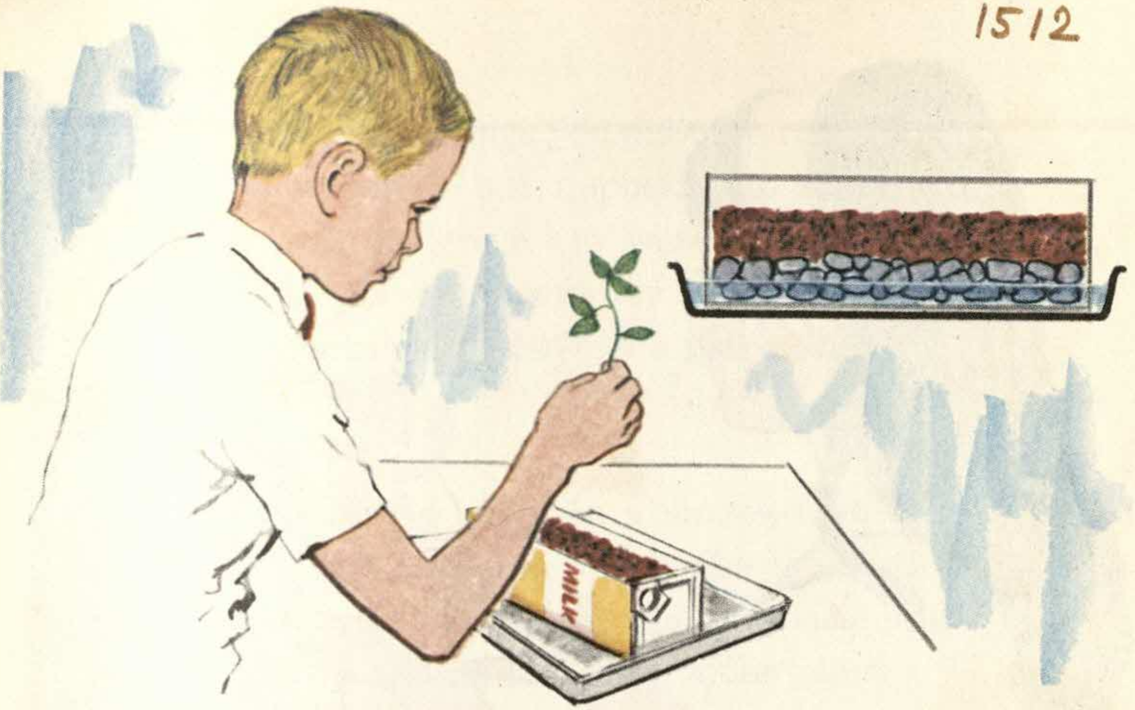

ACTIVITY

Cut away one side of a milk carton. Punch a few small holes in the bottom.

Put one inch of gravel in the carton. Cover the gravel with one inch of topsoil.

Place the carton in a pan of water until the topsoil is moist.

Take two small leafy plants of the same size. Cut the root off one plant. At one end of the carton, make a hole in the soil for the rooted plant. At the other end of the carton, plant the one without a root. Flatten the soil around the plants.

Watch the plants for a few days.

What do you observe?

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ACTIVITY

Put the carton of plants in front of a rotating fan. What happens?

How do roots help to hold a plant in place? How do you think the size of the root system matches the size of the plant? Do tree roots match the size of the tree?

Why do some plants have roots that grow out at the base of the stem?

In all the things you did with roots, you used water. What happened to the root that was not given any water? What happens to plants in very dry weather?

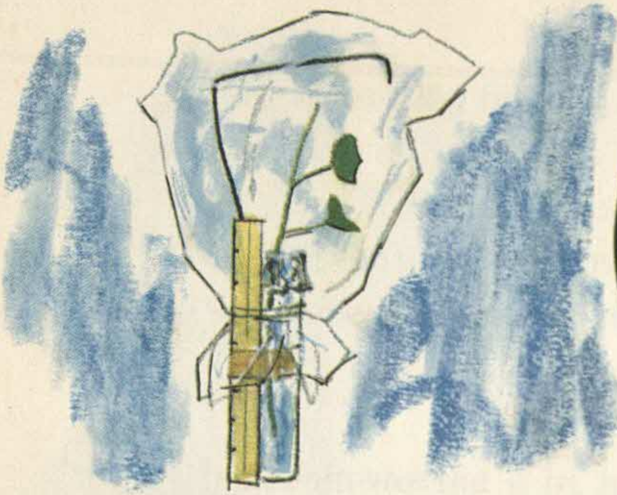
How much water can a plant soak up?

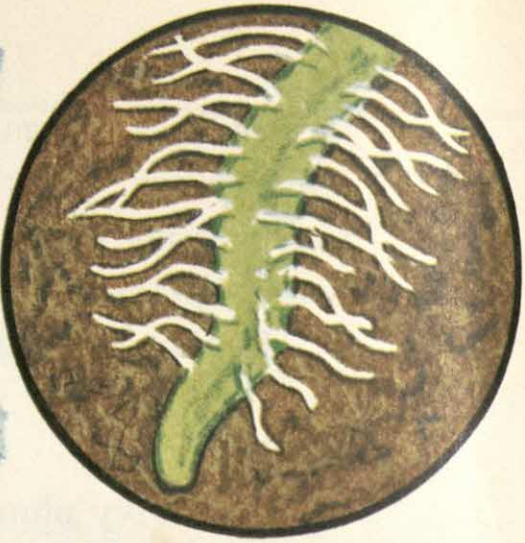
ACTIVITY

Put an ivy plant in a narrow-mouthed bottle full of water. Cover the top of the bottle with aluminum foil. Fit the foil carefully around the stem of the plant.

RECORD

Tape a small ruler to the side of the bottle and mark the water level. Keep a record of the water level from day to day.





After watching your plant for a few days, cover it with a plastic bag. A piece of a coat hanger will keep the bag from touching the plant. Tie the end of the bag around the top of the bottle.

Look at the plant the next day. What do you notice on the inside of the bag? Where did it come from?

OBSERVE

Cut a small root from the plant. Examine it under a magnifying glass. What do you see?

The roots of the plant take in water through tiny root hairs that grow along the root. These tiny root hairs push between pieces of soil and in cracks of rock, growing toward water. When you transplant a plant, why must you be careful of these root hairs?

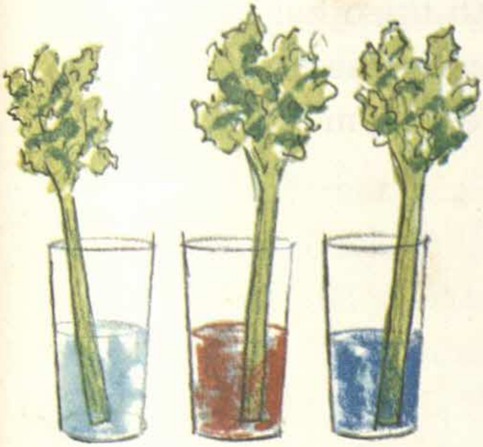
Stems

How are stems important to a plant?

ACTIVITY

Take three pieces of celery with leaves. Cut an inch off each stem.

Place one stem of celery in clear water. Put another stem in red ink, and another in blue ink. Examine the celery during the next few days. What do you notice?



After three days, take a piece of celery from one of the inks and cut across the stem. Examine the cut ends with a magnifying glass. What do you see? How does the water travel from the root? Where does it go?

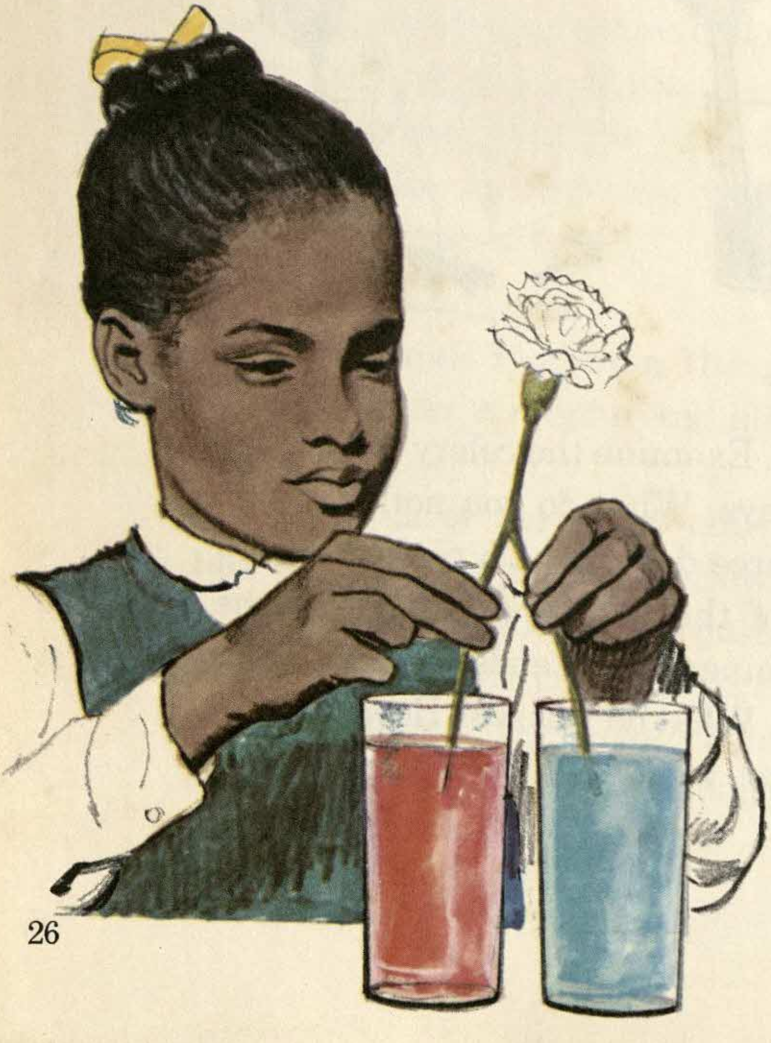
ACTIVITY

Split the stem of a fresh carnation and put one end in a glass of water colored with blue ink and the other in a glass of water colored with red ink.

COMPARE

After one day compare the half of the plant in the red water with the other half.

What do you see? How is the stem of the carnation like the celery stem?



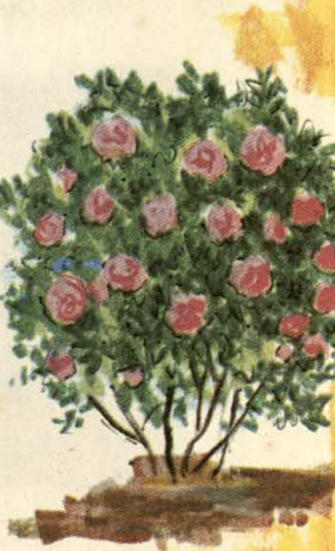
Stems act as pipelines. They carry water from the roots to the leaves. Stems hold up the leaves. What are some stems that we eat? Why do you think we cook most stems?

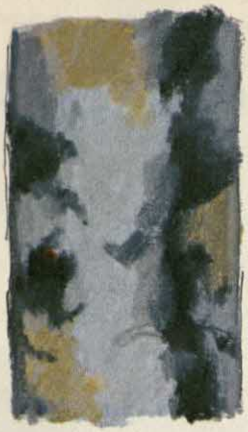
Different plants have different stems. Look at the stem of a small flower and then look at the trunk of a tree. What a difference!

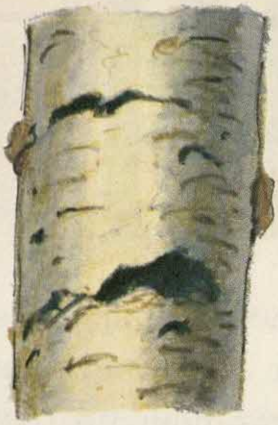
The trunk is the stem of the tree. Most trunks are covered with bark that protects the growing part of the tree. Examine the bark of a tree. What color is it? Is it smooth or rough, plain or patterned, one piece or many?

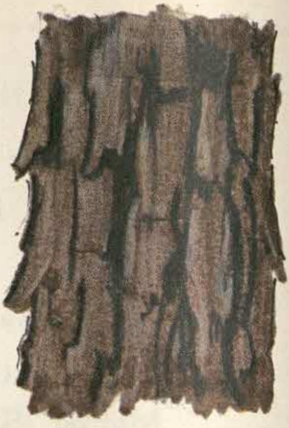
COLLECT

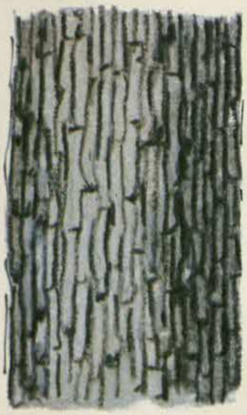
Start a collection of different kinds of bark. Look for pieces of bark on the ground.

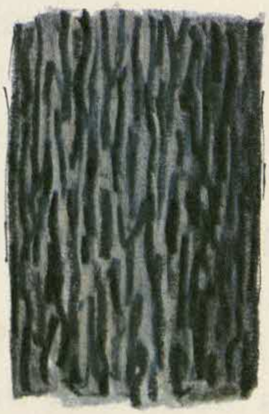


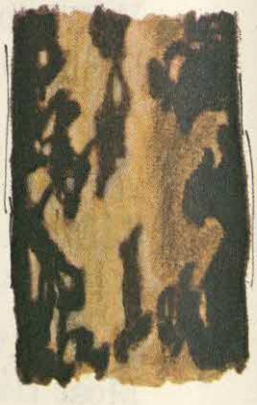

Beech

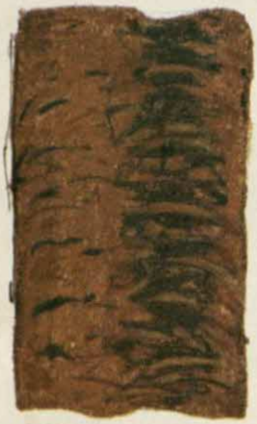

White Birch

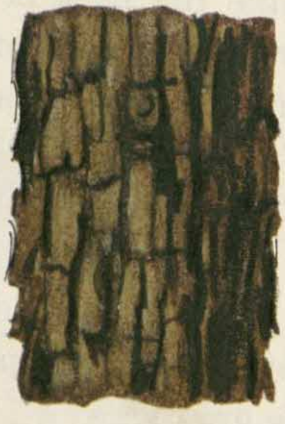

Shagbark Hickory

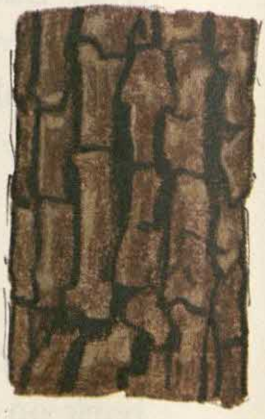

White Oak

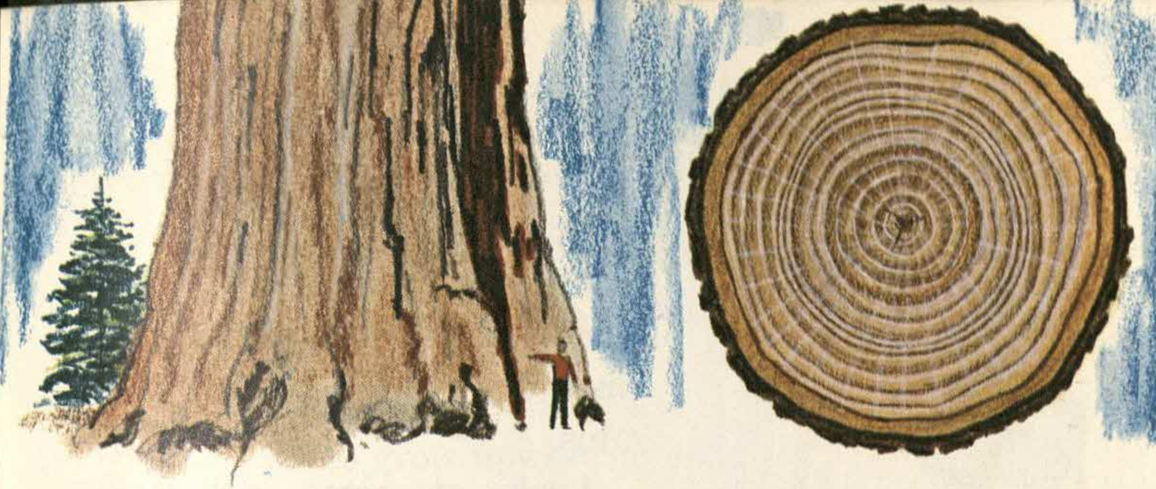

White Ash


Sycamore


Bird Cherry


Sugar Maple


Pitch Pine



The bark of the redwood trees of California is 6 to 12 inches thick. Many of these trees measure more than 10 feet through the center of the trunk. The biggest one measures about 37 feet through the center. This tree is called the General Sherman tree. It is the largest living object on earth. Its "stem" is over 272 feet high, and 100 feet around at its base. It may be more than 3,500 years old.

OBSERVE

Look at the redwood tree above. How do you know it is a young tree?

Look at the picture of the end of a tree trunk. Count the rings. The number of rings tells the age of the tree. How many rings would the General Sherman have?

Some rings are wider than others.

What might this mean?

Every plant needs water, but in some parts of our country there is very little water. The stems of certain plants store water for the long dry period between rains.

Look at some desert plants. Why is the stem the biggest part? Where are the leaves?

ACTIVITY

Plant some cactus plants in sandy soil in a large glass dish. Keep them in the sunlight. What animals would like your desert garden?

Some stems are underground. Two examples are the potato and the onion. Some stems are climbers and crawlers. Look at the pictures.

Water Lily

Cattail

Wheat

Stems grow upward in different ways. Look at the trunks of many trees. Look at the stems of many bushes and flowering plants.

CLASSIFY

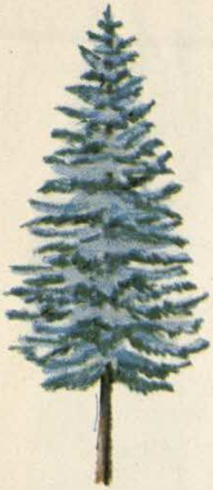
Group the trees on the next page by shape. Which of the trees look like triangles? Which ones are round? Do any of these trees grow near your house?

The spruce, fir, cedar, pine, and hemlock are evergreen trees. Their needle-shaped leaves stay green all year. What shape are these trees?

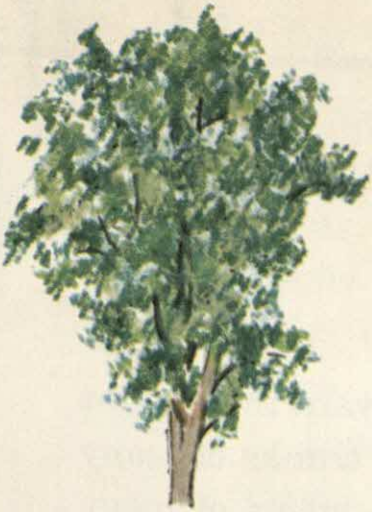
The cottonwood, maple, oak, and horse chestnut have broad leaves. In cold places, broadleaf trees lose most of their leaves in the fall. Winter is a good time to study the shapes of these trees.

Bamboo

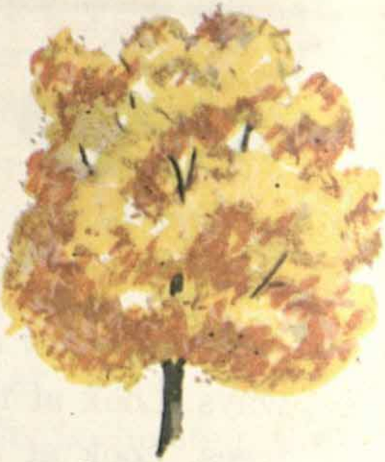
Spreading Yew



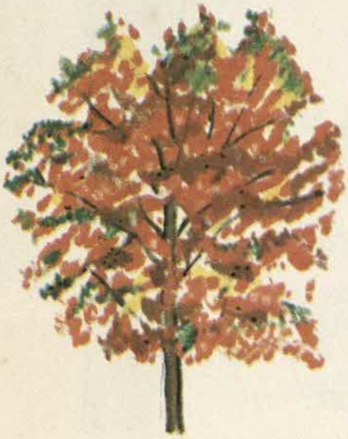
Spruce



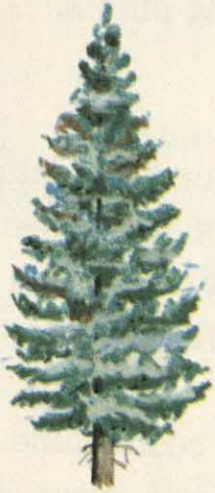
Cottonwood



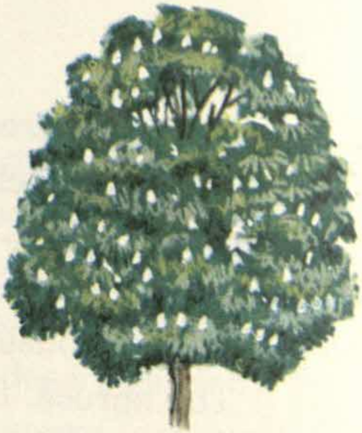
Sugar Maple



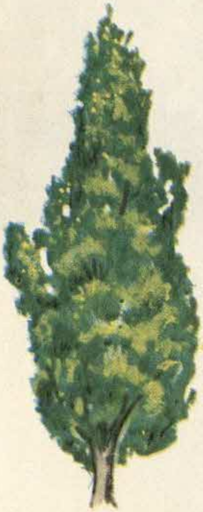
White Oak



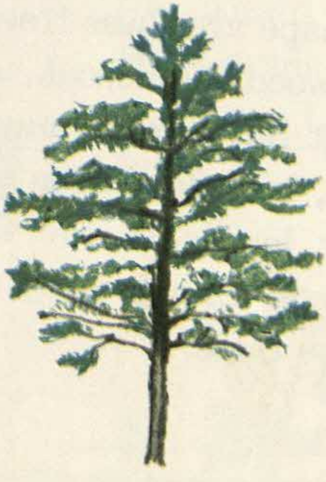
White Fir



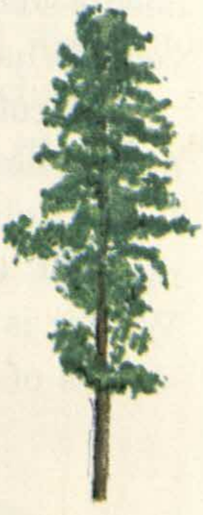
Horse Chestnut



Cedar



Pitch Pine



Hemlock

Leaves

Do you remember what happened when you covered a plant with a plastic bag? Did the water come from the stem or the leaves? Let's find out.

ACTIVITY

Take two small geranium plants. Put each in a pan of water until the soil on the top feels damp.

Take the plants from the water. Cover one with a plastic bag. Tie the bag around the bottom of the stem.

Take all the leaves off the second plant. Cover the plant with a plastic bag. Tie the bag around the bottom of the stem.

Put the plants in a warm sunny place. Keep the soil moist. Watch the insides of the plastic bags. What happens? Why?

Why do evergreens and desert plants have such small leaves?

Root hairs take water into the roots. The water is pulled up through the stem to the leaves. The leaves may give off moisture. Do plants need water to live? What else do they need?

ACTIVITY

Take three plants about the same size. Measure the height of each. What color are the leaves? What color are most leaves?

Count the number of leaves on each of your plants. Keep a record of what you see and measure.

Put the three plants in a sunny place. Label them X, Y, and Z.

Do nothing to X. Cover Y with a cardboard box. Cover one leaf of Z with black paper. Clip two small triangles of stiff paper to the top and bottom of another leaf on Z.

After a week, examine each plant. Check your record. What has happened?

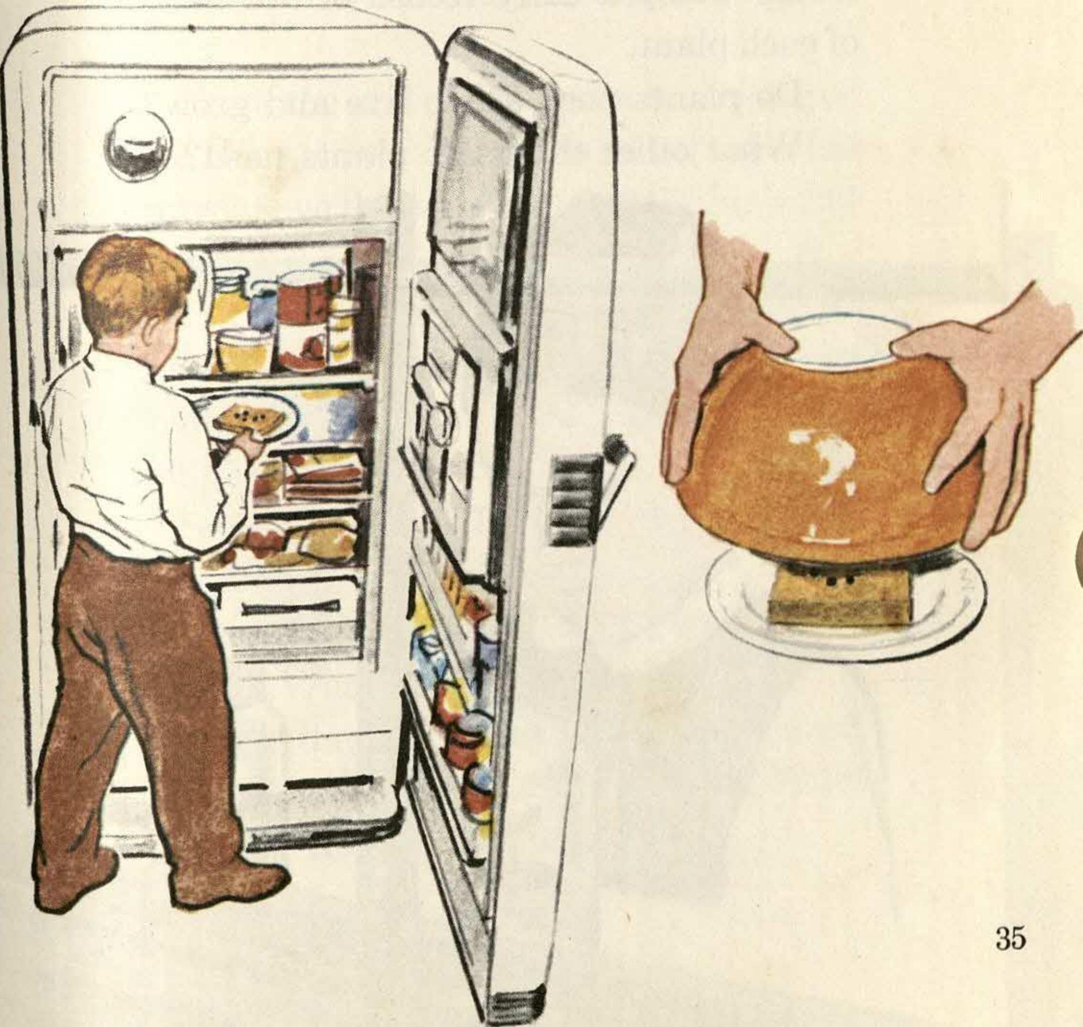
ACTIVITY

Does warmth help plants to grow?

Put two wet sponges on two saucers of water. Place some radish seeds on the sponges.

Put one dish in a refrigerator. Put the other dish in a closet or cover it with a bowl and keep it in the room.

Look at the seeds each day for five days. What has happened?



ACTIVITY

Can plants live and grow without air?

Grow two small plants in two small cans. Put a few small holes in the bottom of each can.

Place the cans in glass jars that have a little water in them.

Screw the lid on one jar and leave the other jar open. Put both plants in a warm sunny place. Look at them each day for two weeks. Keep a daily record of the height of each plant.

Do plants need air to live and grow?

What other things do plants need?

ACTIVITY

Fill a glass jar with water to about 2 inches from the top. Fit two plastic straws into a cork which fits the top of the glass jar.

Have the end of one straw in the water. Call this straw C. Have the end of the other straw above the water level. Call this straw D.

Put the stem of a leaf into straw C. Fasten the stem into the straw with clay. Cover the cork with clay so that it is airtight.

Suck air out of D. Close the end with your finger. What happens?

Remove your finger and repeat what you did. What happens? Why?

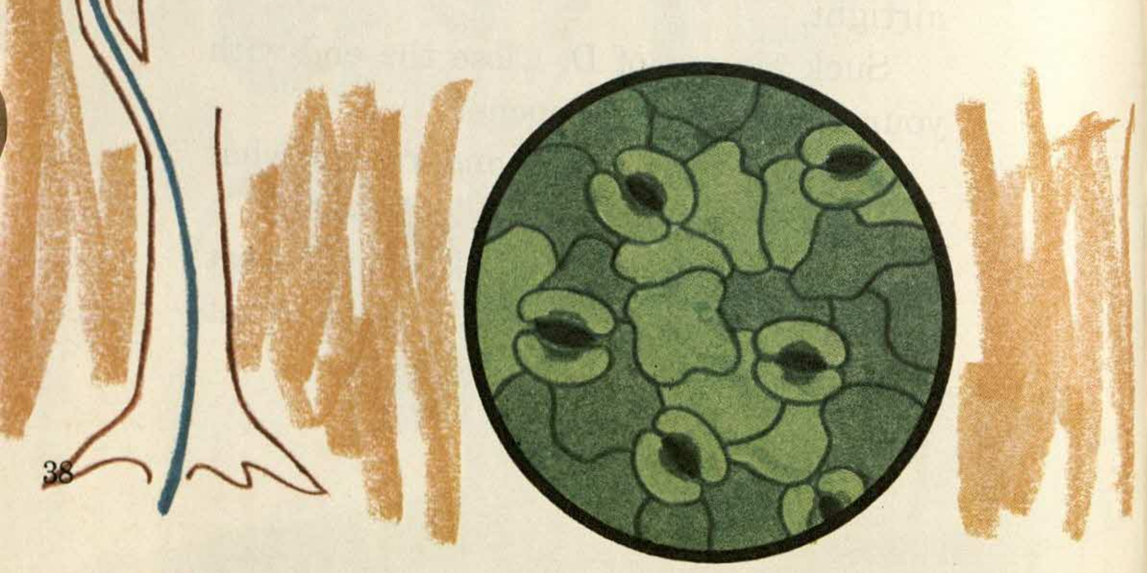
Cover the leaf with vaseline and repeat the test. Be sure the cork is airtight. What happens? How do plants get air?

There are tiny openings in the leaves of plants. These openings are too small to see with your eyes, but you did see the air bubbles that came from the leaf. Most land plants have these openings on the underside of the leaf. Where do you think plants like water lilies have their leaf openings? How could you find out?

Through these tiny openings in the leaf, the plant gets air. All living objects need air, but green plants also use the air to make their food. To do this, green plants need sunlight, air, and water. The making of food out of air and water in sunlight is called photosynthesis (*foh*-toh-SIN-thuh-sis).

Why are green plants important to us? Why are they important to animals?

Try to imagine our world if it had no plants.



Green leaves are alike in what they do. They are the food factories for the plant.

Are they alike in shape?

COMPARE

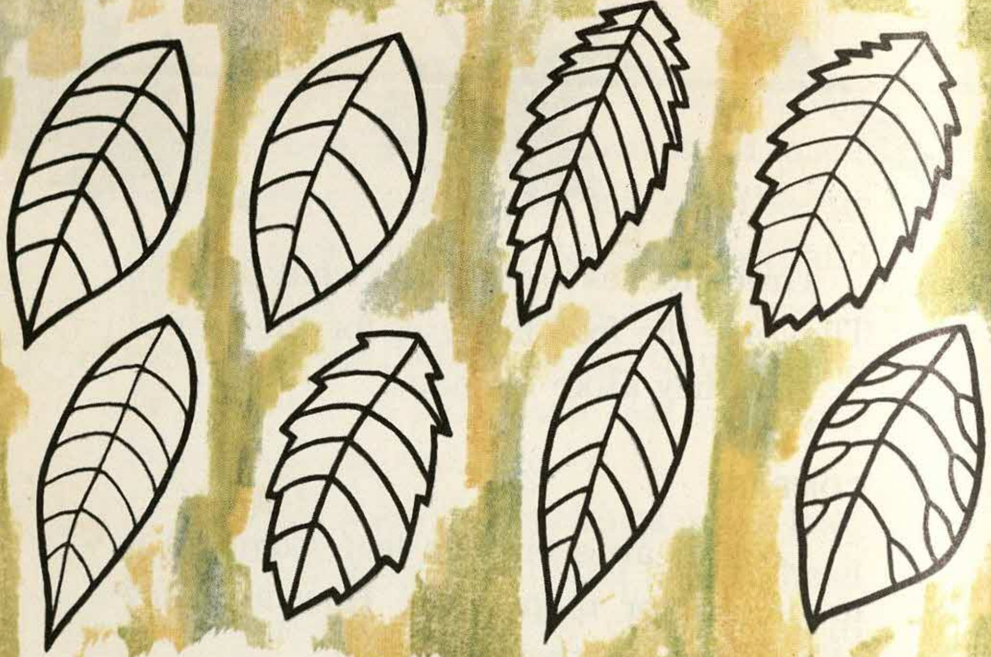
Look at an evergreen leaf. Compare it to an oak or maple leaf. How are they alike? How are they different?

Do all broadleaf trees lose their leaves in autumn?

Does the shape of an evergreen leaf help the tree when it snows?

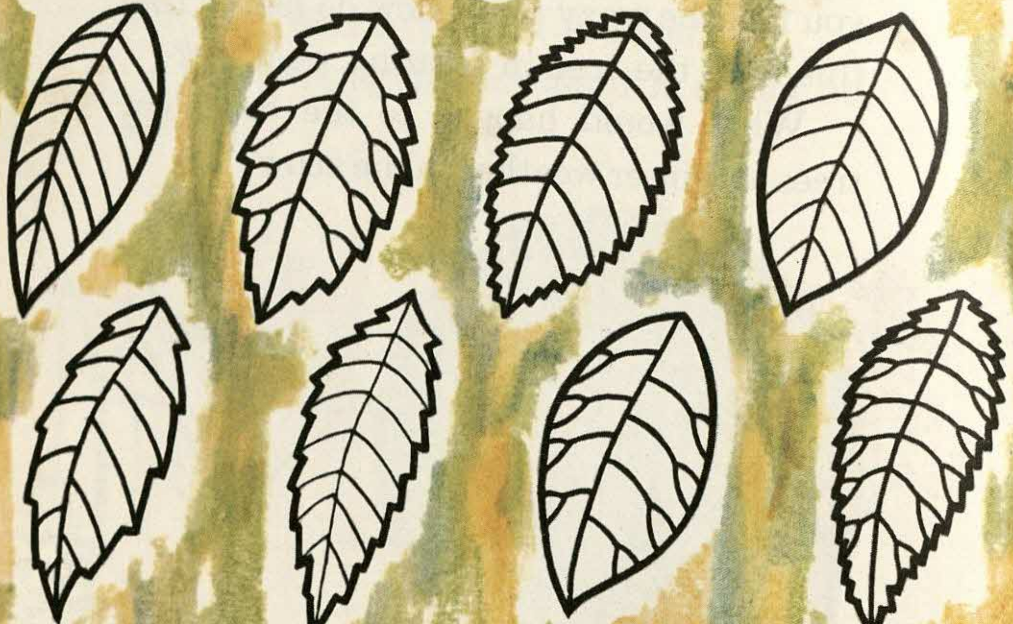
Feel the needles of an evergreen. Can you feel the waxy coat? How do leaves like this help the tree in freezing weather?

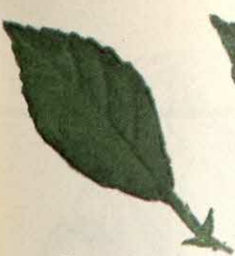
What would happen to the broadleaf trees in winter weather in the snow?



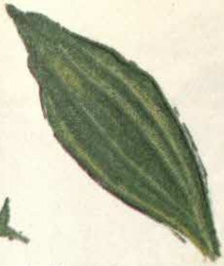
CLASSIFY

Can you group these leaves? How are these leaves alike? How are these leaves different?

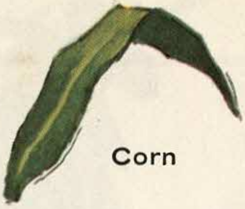




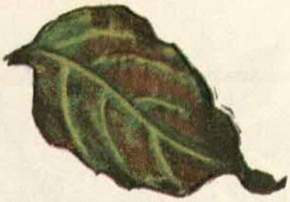
Rose



Lily of the Valley



Corn



Dogwood

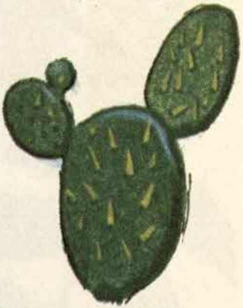
Broadleaf plants have leaves of many shapes, sizes, and colors. These plants all have flowers.

INVESTIGATE

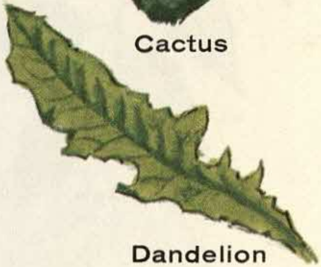
Leaves can help you to identify plants. Do leaves grow on stems in different ways? Look at the shape of each leaf. Are the edges of the leaf smooth, wavy, or divided into parts? Are the points sharp or round?

The shape of the leaf depends on the veins. Look at the vein patterns of these leaves. Find the ones that look like the lines in the palm of your hand. Find any vein pattern that looks like a feather, with one heavy line and many fine lines branching from it. Find the veins that look like railroad tracks.

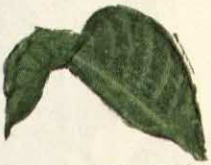
Try to find samples of these leaves. Start a leaf collection.



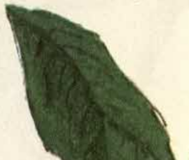
Cactus



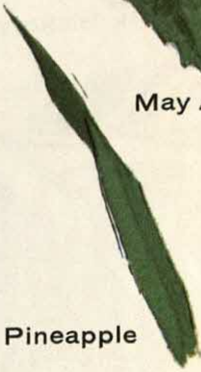
Dandelion



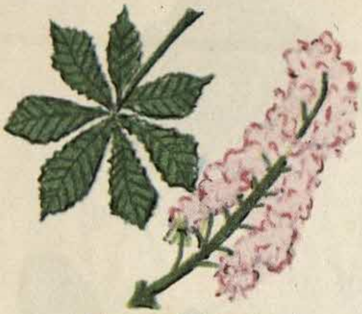
Jack in the Pulpit



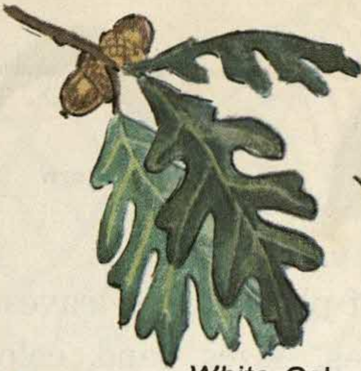
May Apple



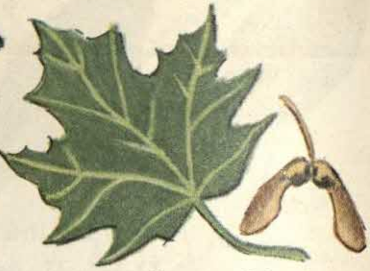
Pineapple



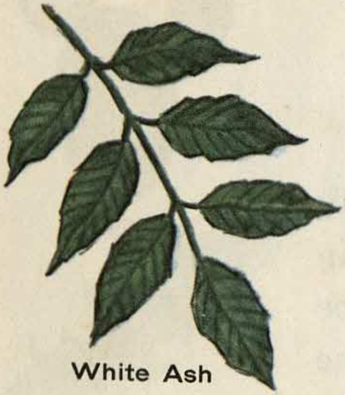
Horse Chestnut



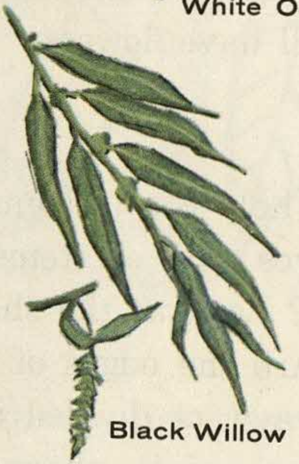
White Oak



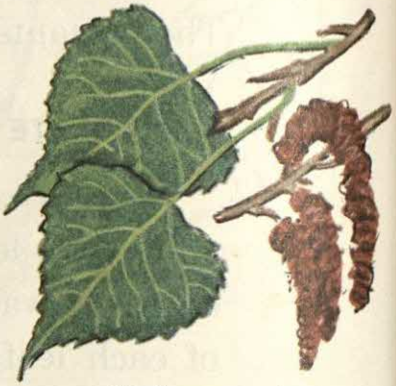
Sugar Maple



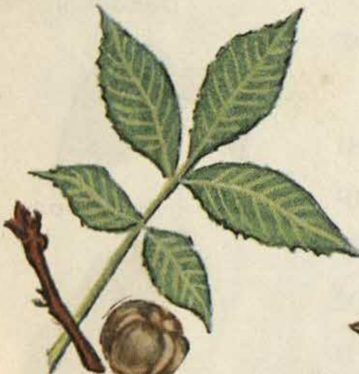
White Ash



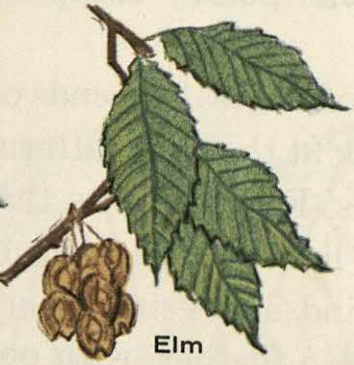
Black Willow



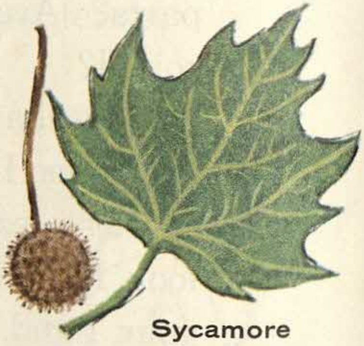
Cottonwood



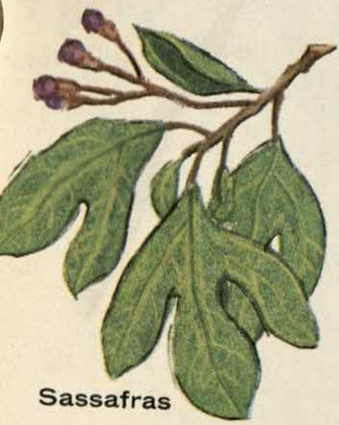
Shagbark Hickory



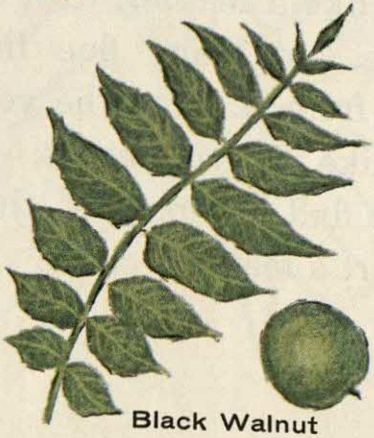
Elm



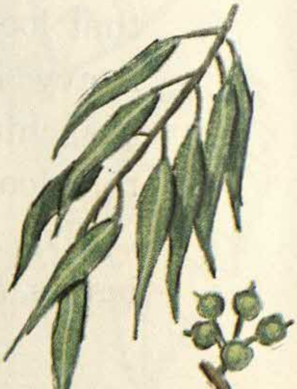
Sycamore



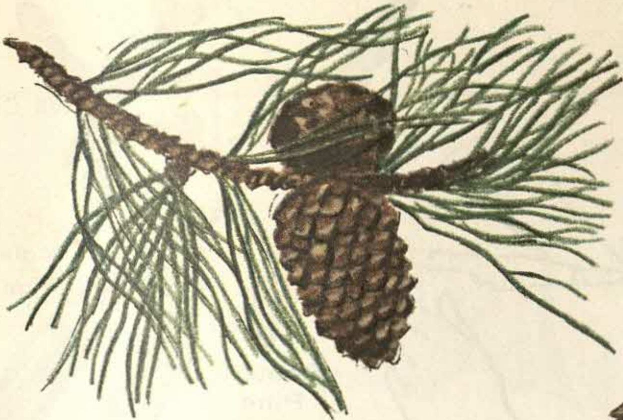
Sassafras



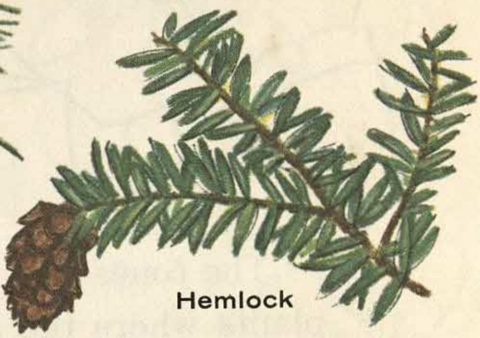
Black Walnut



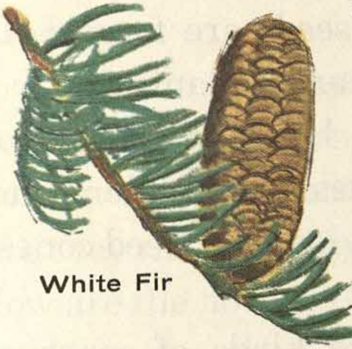
Eucalyptus



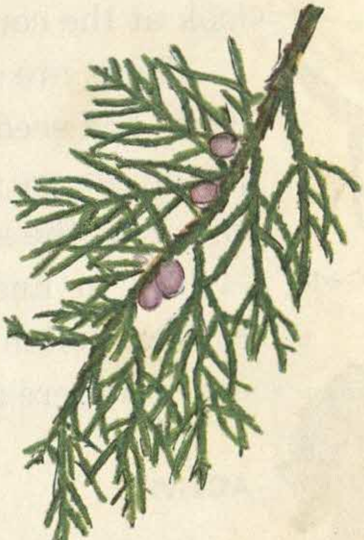
Pitch Pine



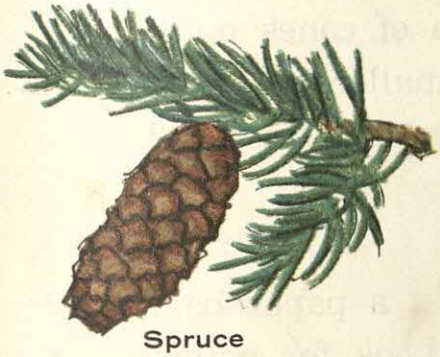
Hemlock



White Fir



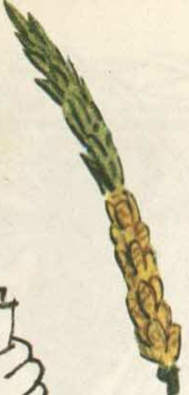
Cedar



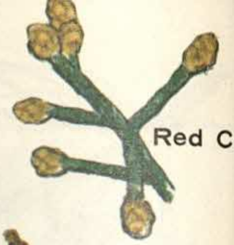
Spruce

Cones and Flowers

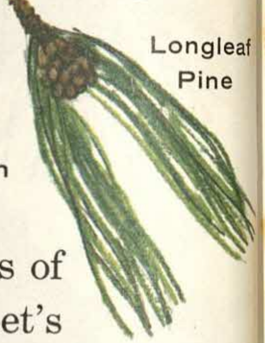
Most evergreen trees have cones. Evergreen trees are called conifers (KOH-ni-furz). How many of the conifers on this page have you seen? Look at the leaves of the conifers. Are they single or in bundles?



Scotch Pine

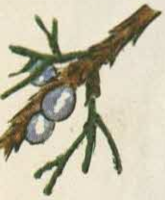


Red Ced



Longleaf Pine

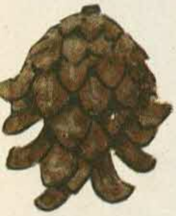
The cones and flowers are the parts of plants where the seeds are formed. Let's look at the cone-bearing plants first.



Red Cedar

There are two kinds of cones, pollen cones and seed cones. Some pollen cones of pine trees are shown above. Seed cones are shown at the side.

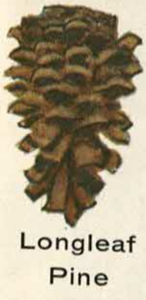
Try to find two kinds of cones on a conifer. Pollen cones are smaller than seed cones. Where are the pollen cones located?



Scotch Pine

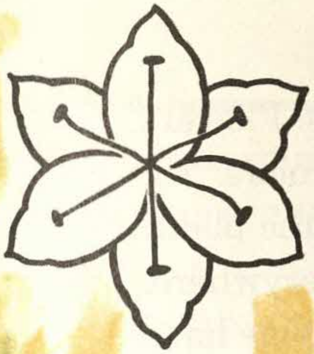
ACTIVITY

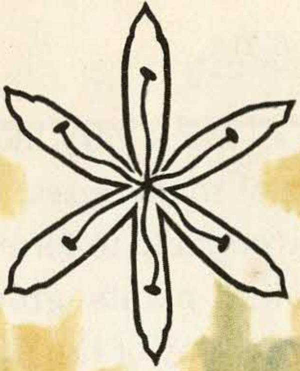
Shake a pollen cone in a paper bag. Open the bag carefully. Look for pollen with a magnifying glass.



Longleaf Pine

Wind carries some pollen to buds in the seed cones. When the seeds are ripe, they fall out from between the scales of the cones. Examine a seed cone. Why does a tree need so many seeds?





Do all plants have the same kind of flowers?

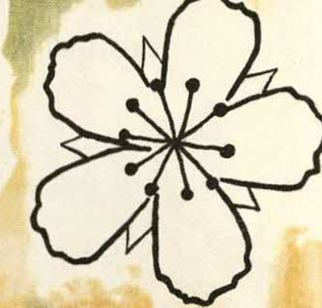
Are they the same color?

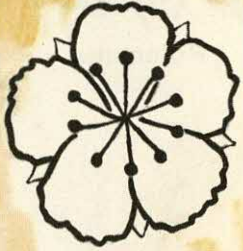
Do they have the same smell?

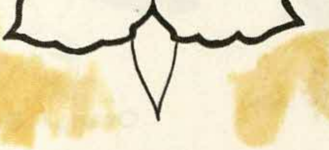
Do they feel the same?

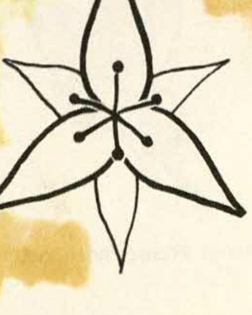
Are they the same size?

How are the flowers on this page alike? How are they different?

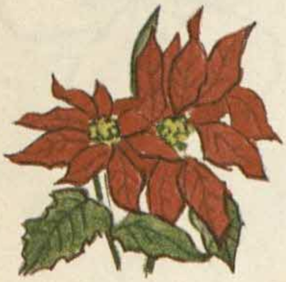








Flowers vary more than cones. Flowers are of many sizes, shapes, and colors. All flowers help to form the seeds of the plant. Flower plants grow almost everywhere. How many of the flowers on this page have you seen? There is a surprise! The flower of the poinsettia is the yellow part in the center. The red parts are leaves.



Poinsettia

Orchid

Violet

Daisy

Prickly Pear Cactus

Apple Blossom

Swamp Rose Mallow

Indian Paintbrush

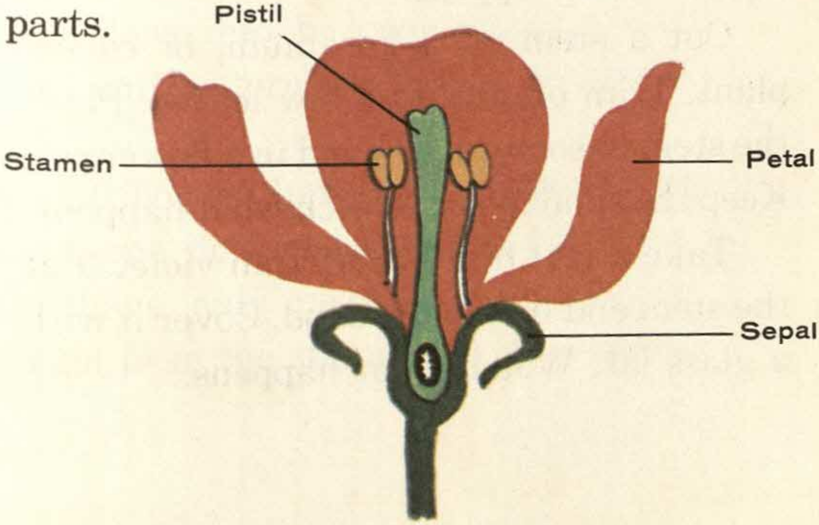
Orange Blossom

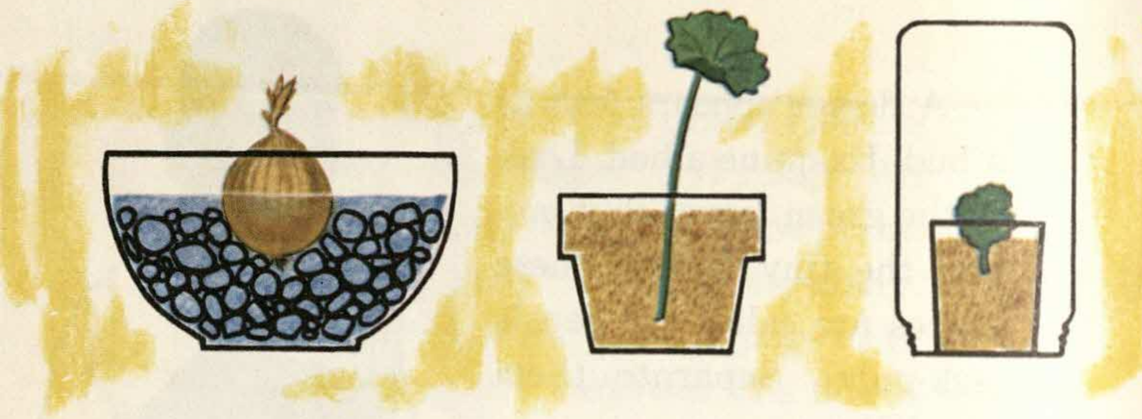
A flower appears first as a bud. Examine a bud. Look at the green leaves that protect the tiny flower. These leaves are called the sepals (SEE-pulz). Separate them carefully.

ACTIVITY

Bring a lily, rose, tulip, or petunia to school. Compare your flower with the diagram below.

Carefully pick out the colored petals until you get to the center of the flower. Two parts may be found in the center. Use a magnifying glass to help you find these parts.





Most of the plants you know come from seeds. Some plants can start from stems. Bulbs are short stems with leaves.

Some plants can start from underground stems or stems that root on the ground. Others can start from leaves.

ACTIVITY

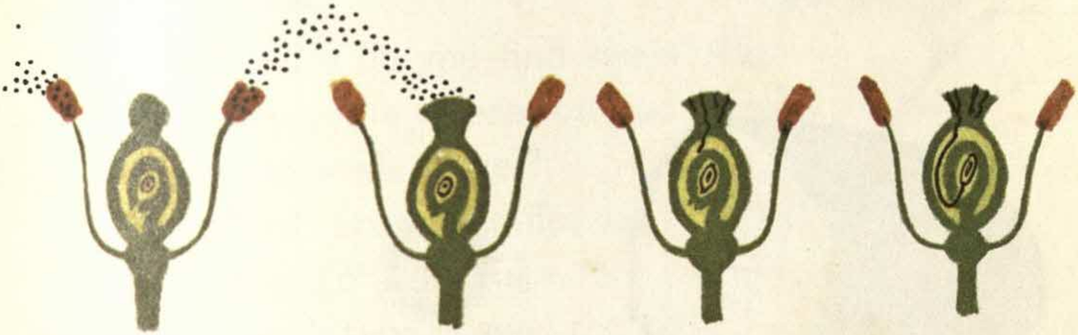
Fill a bowl with gravel and put some narcissus bulbs, onion bulbs, or other kinds of bulbs in the gravel. Fill the bowl with water and put it in a dark cool place. Watch what happens.

Cut a stem off a geranium, or coleus plant. Trim off all but a few leaves. Plant the stem in some moist sand in a flower pot. Keep the sand moist. Watch what happens.

Take a leaf from an African violet. Put the stem end into damp sand. Cover it with a glass jar. Watch what happens.

ACTIVITY

In the center of the flower you may see many little stems with yellow tops. These are called stamens (STAY-menz). Touch the tops. The yellow dust that sticks to your finger is the pollen. Try to open a stamen with a pin. Is there any pollen? What insects help to spread the pollen?



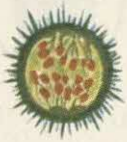
The part in the center that looks like a short green vase is the pistil (PIS-tihl). If the pollen falls on the top of the pistil, it will grow down into the lower section where the seed will be formed. Why is the pistil sticky?

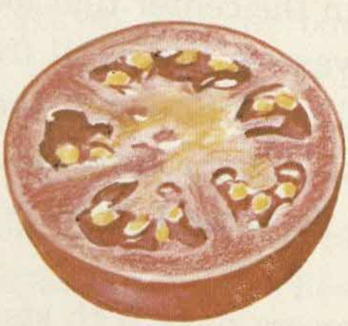
Not all flowers have both stamens and pistils. Some flowers have only stamens. Others have only pistils. How can the pollen get from the stamens to the pistils?

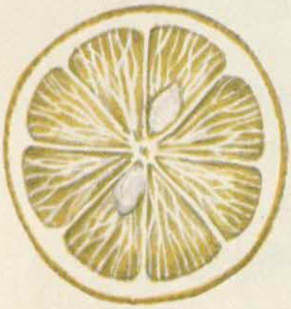
The plants that have fruits, nuts, berries, or pods start from seeds. What fruits do you know that have seeds inside?

The fruit is food for the seed until the new plant begins to make its own food. Corn, peas, and beans are seeds. These seeds have food supplies for the new plant.

Some seeds have no food supply. The seeds of the pine tree have no covering of food.



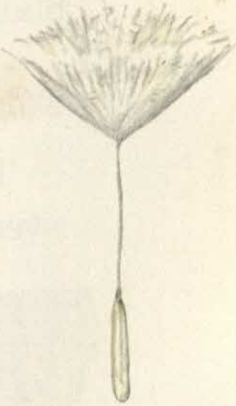


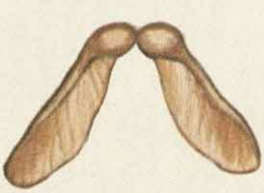


Where do you find seeds? How do they get to where you find them? How do seeds travel?

Seeds are very different. Look at the seeds on this page. Can you tell how each type of seed travels?

Try to find some seeds that blow in the wind, that stick to your clothes, or that are "shot" out of a pod.





By now you may have many interesting questions to ask about plants. Do plants always grow toward the light? Do different colored lights do anything to their growth? What kind of soil is best for growing plants?

EXPLORE

Try an experiment of your own to answer a question you have about plants.

Seedless Plants

Some plants have no flowers or cones so they cannot have seeds. Ferns and mosses have no seeds.

OBSERVE

Look at a fern leaf. What do you see on the back of the leaf? Press the back of a fern leaf on paper. Use a magnifying glass to look for tiny specks on the paper. The specks are spores (SPAWRZ). Spores can grow into new plants.

Mosses grow in almost any damp place, except near salt water. Look for mosses in your back yard. Look closely and see how many different kinds of mosses you can find. Notice any caps at the tops. Press one on paper. What do you find?

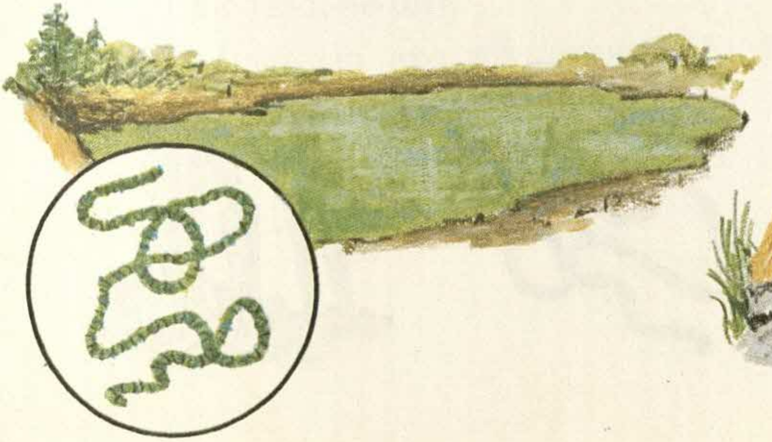
ACTIVITY

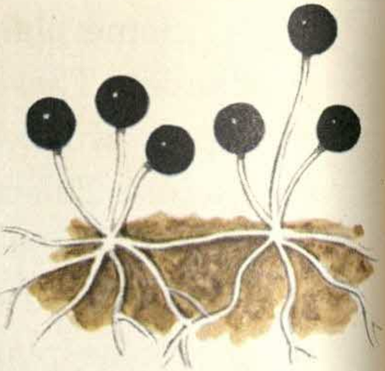
Collect some mosses. Wrap them in a damp newspaper to keep them from drying. You can use a glass jar to make a moss garden. Place about an inch of gravel or pebbles in the bottom, and then an inch of topsoil. Add the mosses and some small ferns. Pour in enough water to cover the pebbles. Cover the mouth of the jar with a plastic sheet and put it in a shady place. Watch your mosses and ferns grow.

Some plants do not have green leaves. These plants cannot make their own food. They grow on other plants. This kind of plant is called a fungus (FUNG-gus). The white plants in the picture are examples.

Some plants have no roots, no stems, no leaves. Have you ever seen a green scum on the water of a pond or on the side of a fish bowl? This is algae (AL-jee). Some algae are green. Algae can make their own food. There are many kinds of algae. Seaweeds are large algae.

There is a two-in-one plant, the lichen (LY-kin). You will find it growing on the bark of trees or on bare rocks. It is both an alga and a fungus. Which part of the plant makes its own food?





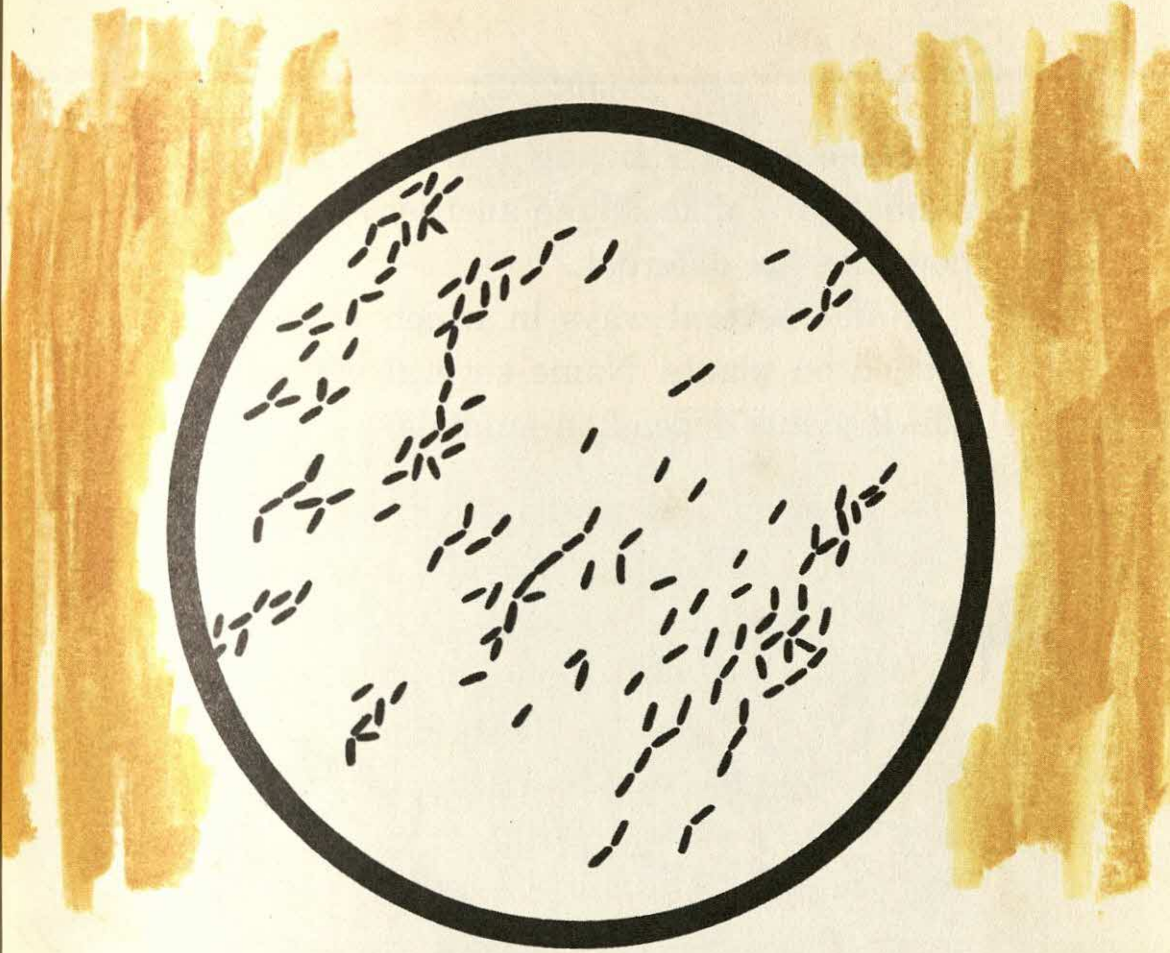
Many plants have roots, stems, leaves, and flowers or cones. These are the seed plants.

There are plants without seeds, but with roots, stems, and leaves. These are the ferns and mosses.

There are plants that cannot make their own food. These are the fungi that live on other plants.

There are plants that have no roots, stems, or leaves. These are the algae.

Then there is the two-in-one, the lichen.



There are even plants that are too small to be seen. They do not have parts. Some of these very tiny plants are called bacteria (bak-TEER-ee-uh).

Bacteria are all around us. Many of them are helpers but some are enemies. Look at the picture of bacteria. It shows the bacteria 1500 times as large as they really are.

THINK

Make a list showing how plants and animals are alike. Make another showing how they are different.

Name several ways in which animals depend on plants. Name several ways in which plants depend on animals.

Are flowers and fruits alike in any way? Try to explain how they are alike.

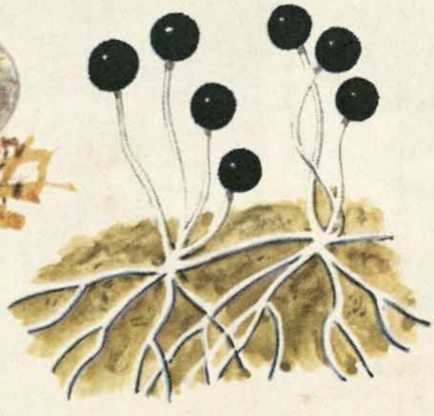
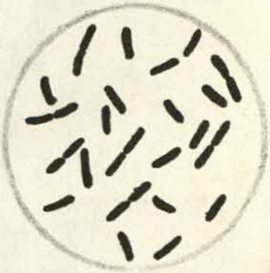
Some people think that plants should be removed from a sick room at night. What do you think?

PROJECTS

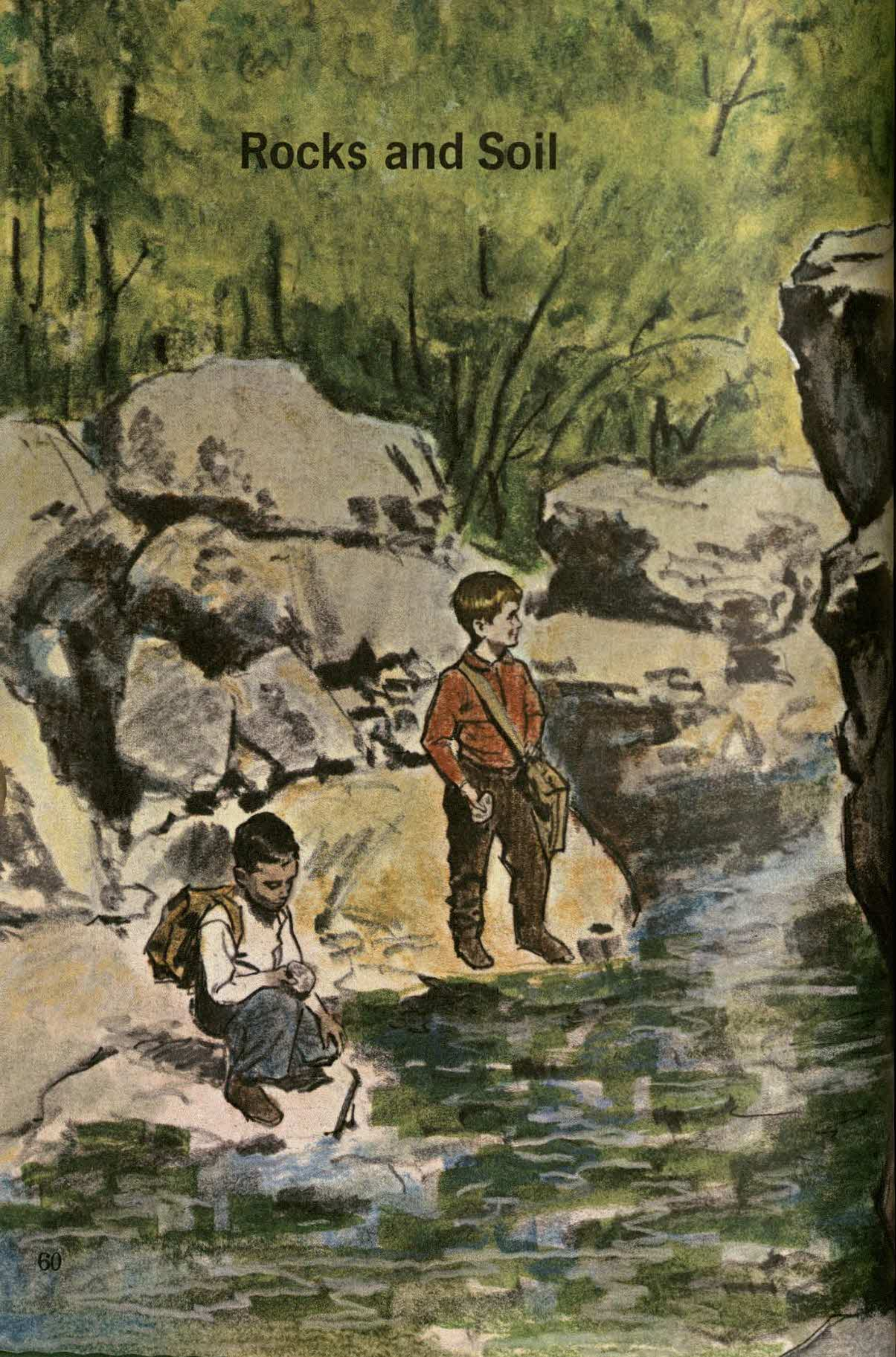
If possible, take a walk close to your home and collect as many kinds of plants and flowers as you can. Classify and display what you collect. How can you explain your classification?

Plan an experiment to see how different colored lights affect the growth of plants. Under which color do they grow best? How could you make use of this knowledge?

Plan an experiment to see if plants grow at the same rate each day. Keep a record of daily growth and graph your results.

Rocks and Soil



DESCRIBE

Are there many kinds of rock?

Pick up a piece of rock.

How does it feel?

What color is it?

Is it heavy or light?

Where did you find it?

COLLECT

Look for different kinds of rock.

Bring them to class.

Try to describe them.

Where did you find them?

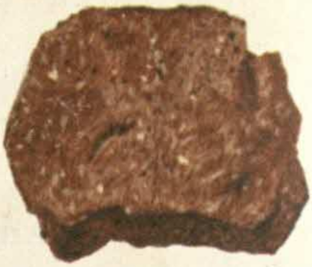
Look at another rock. Are all parts of the rock the same color? Is the rock all one piece, or is it made up of smaller pieces?

ACTIVITY

Wrap the rock in a cloth and break it with a hammer.

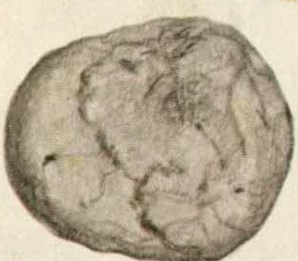
Is the inside of the rock like the outside? If not, how is it different?

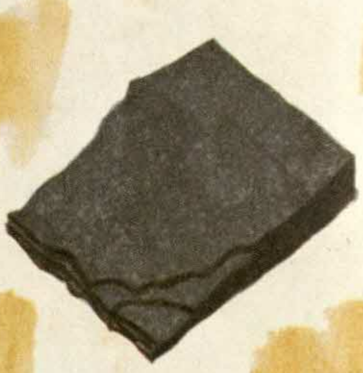
Look at it with a magnifying glass. Describe what you see.

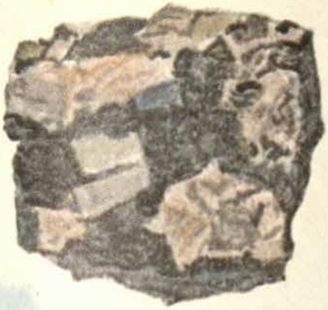


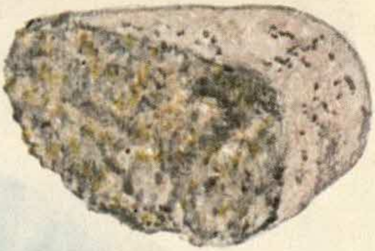
DESCRIBE

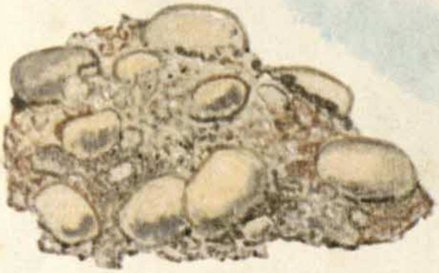
Describe these rocks.
How are they alike?
How are they different?











OBSERVE

Describe these rocks.

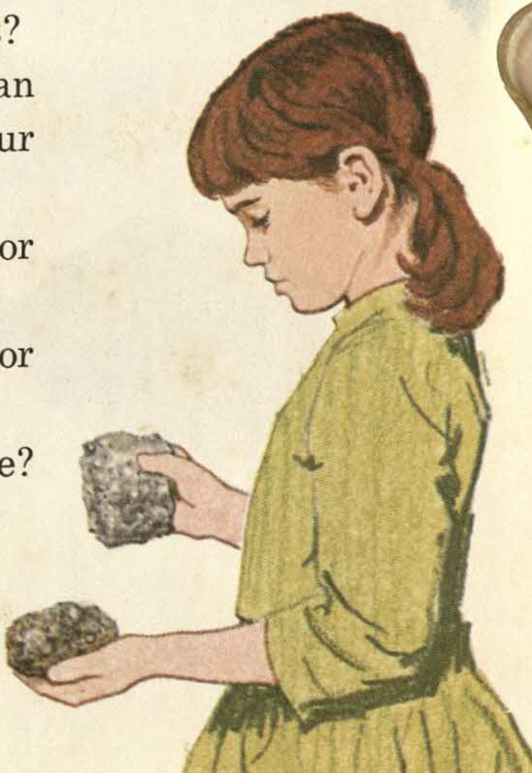
How are they different?

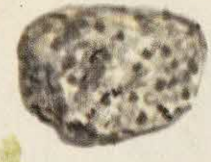
Look at your rock. Can you pick pieces out of your rock?

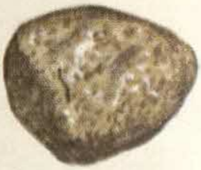
Are the pieces round or sharp?

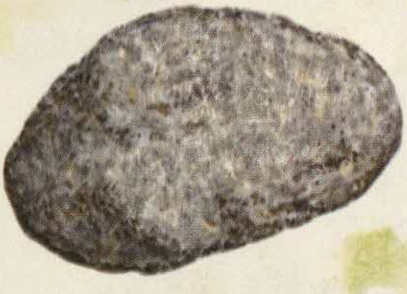
Are the pieces dull or shiny?

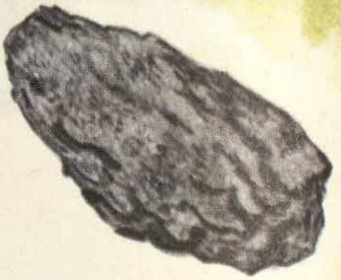
Are the pieces all alike?



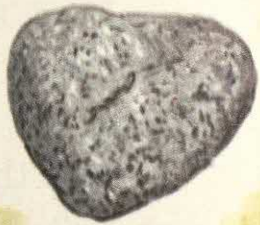


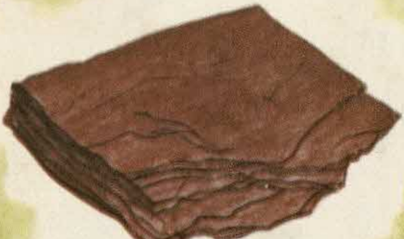


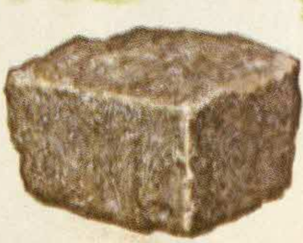




Describe these rocks.
How are they alike?
How are they different?
Where are smooth rocks found?







Are all rocks hard?
What is the hardest rock?
How could you tell?
Are your rocks hard or soft?
How do you tell?

VERY HARD	scratches glass
HARD	knife scratches rock but rock does not scratch glass
MEDIUM	copper penny scratches rock but fingernail does not scratch rock
SOFT	fingernail scratches rock

Where can you see large rocks?
What do we call them?
Where do small rocks come from?
What do we call them?
Where do tiny rocks come from?
What do we call them?

Coal

Obsidian

Diamond

White Marble

CLASSIFY

What have you found out about rocks?

How are some rocks different?

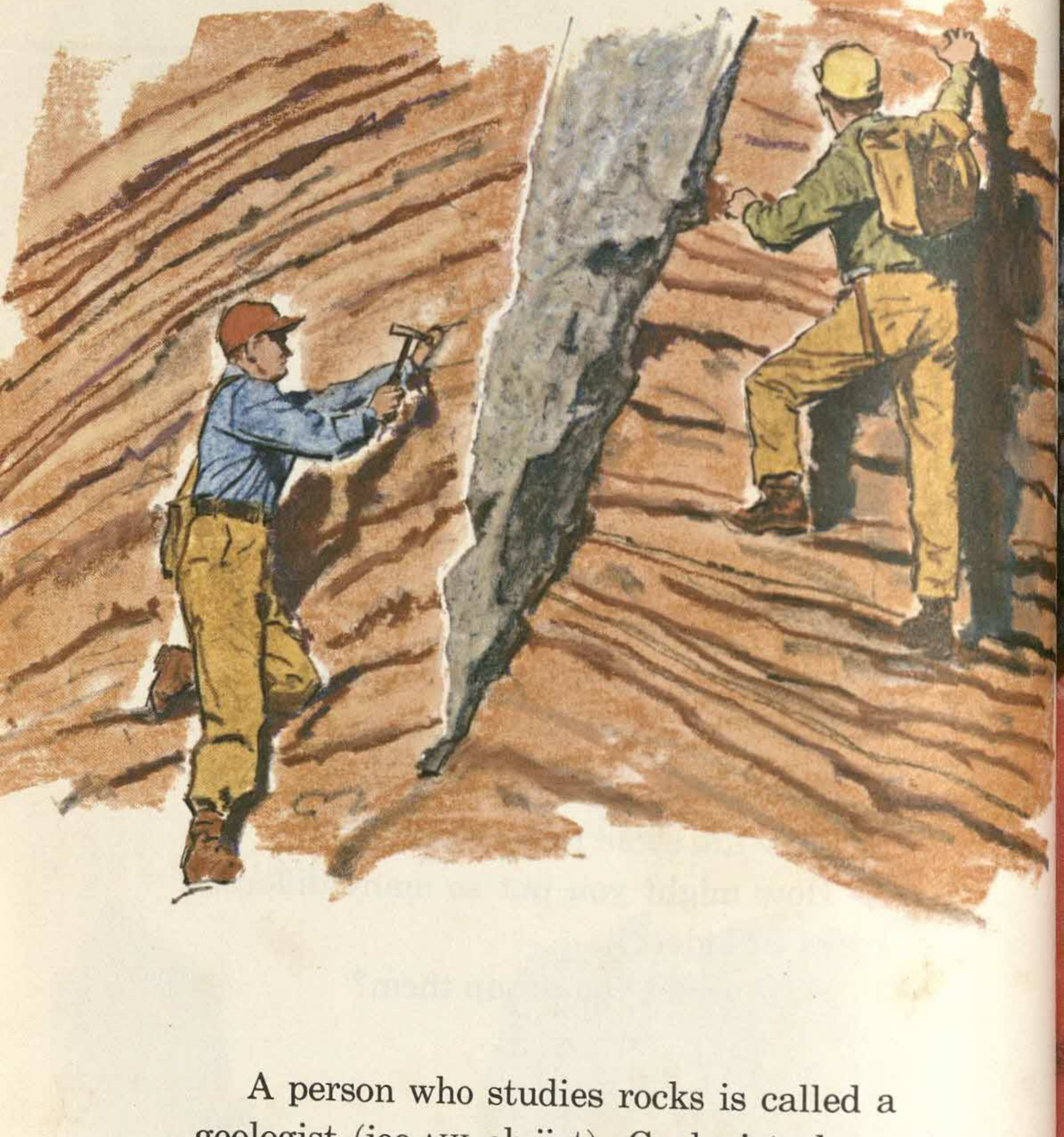
How might you put so many different rocks in order?

How would you group them?

Granite

Shale

Limestone



A person who studies rocks is called a geologist (jee-AHL-oh-jist). Geologists have learned that all rocks on the earth were made in one of three ways. By learning how a rock was formed, a geologist can put any rock into one of three classes. Let's find out how rocks are made.

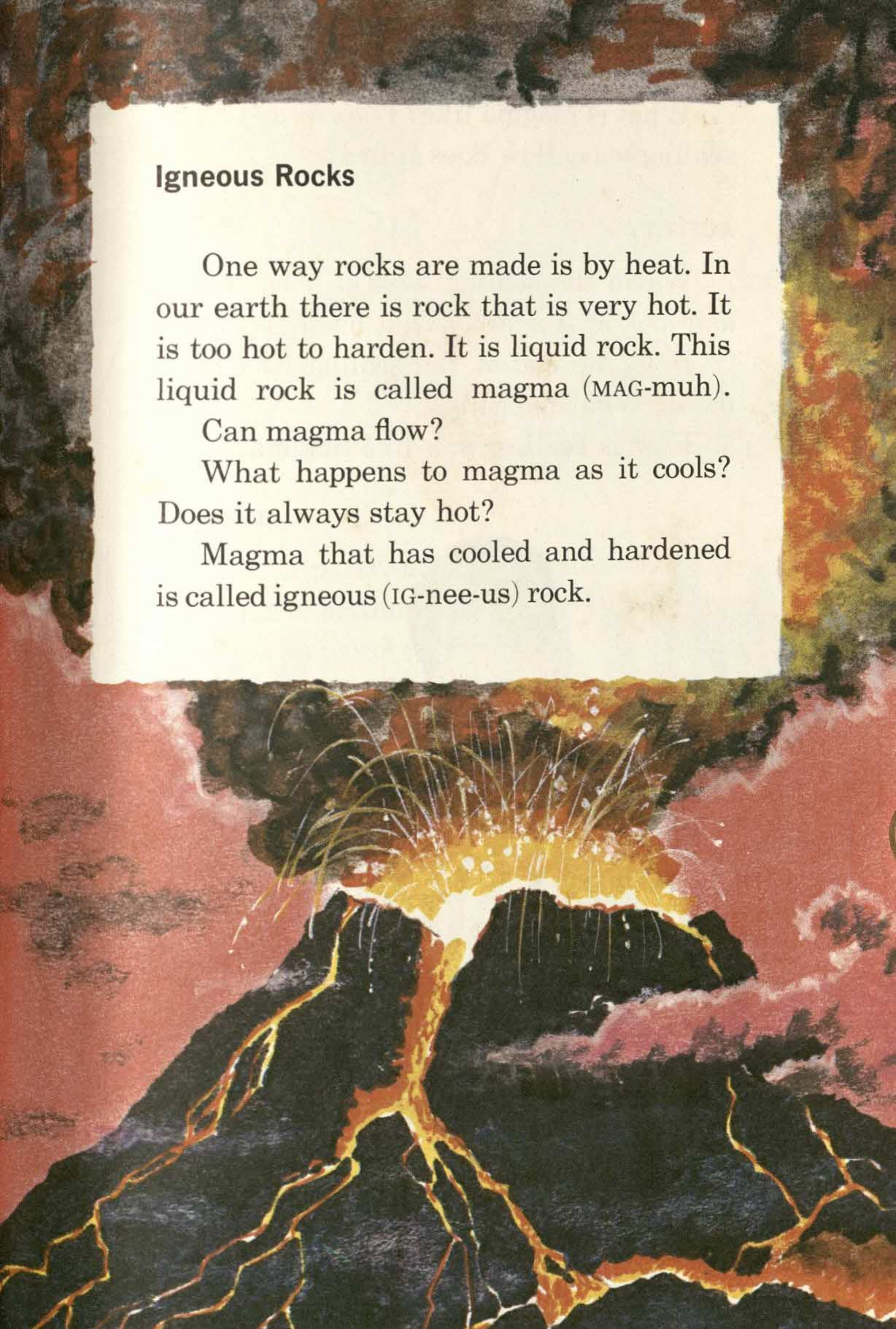
Igneous Rocks

One way rocks are made is by heat. In our earth there is rock that is very hot. It is too hot to harden. It is liquid rock. This liquid rock is called magma (MAG-muh).

Can magma flow?

What happens to magma as it cools? Does it always stay hot?

Magma that has cooled and hardened is called igneous (IG-nee-us) rock.



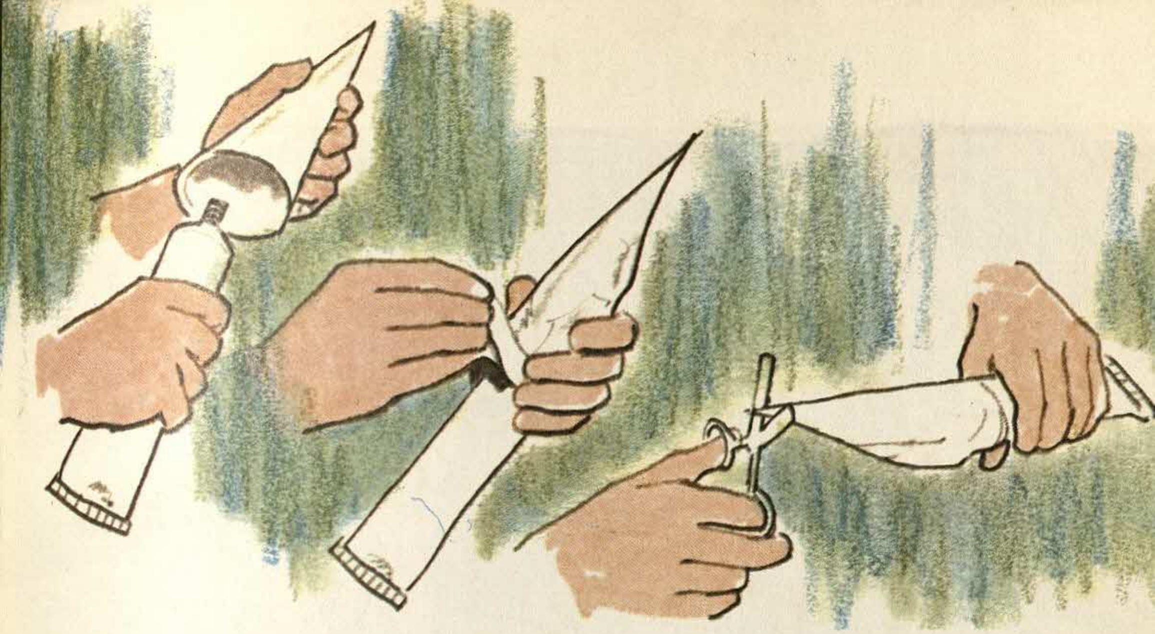
What is magma like? Look at a stick of sealing wax. How does it feel?

ACTIVITY

Warm the sealing wax in a hot place and look at it again. What has happened?

Hold the end of the sealing wax in a flame. What happens?

How is sealing wax like magma?



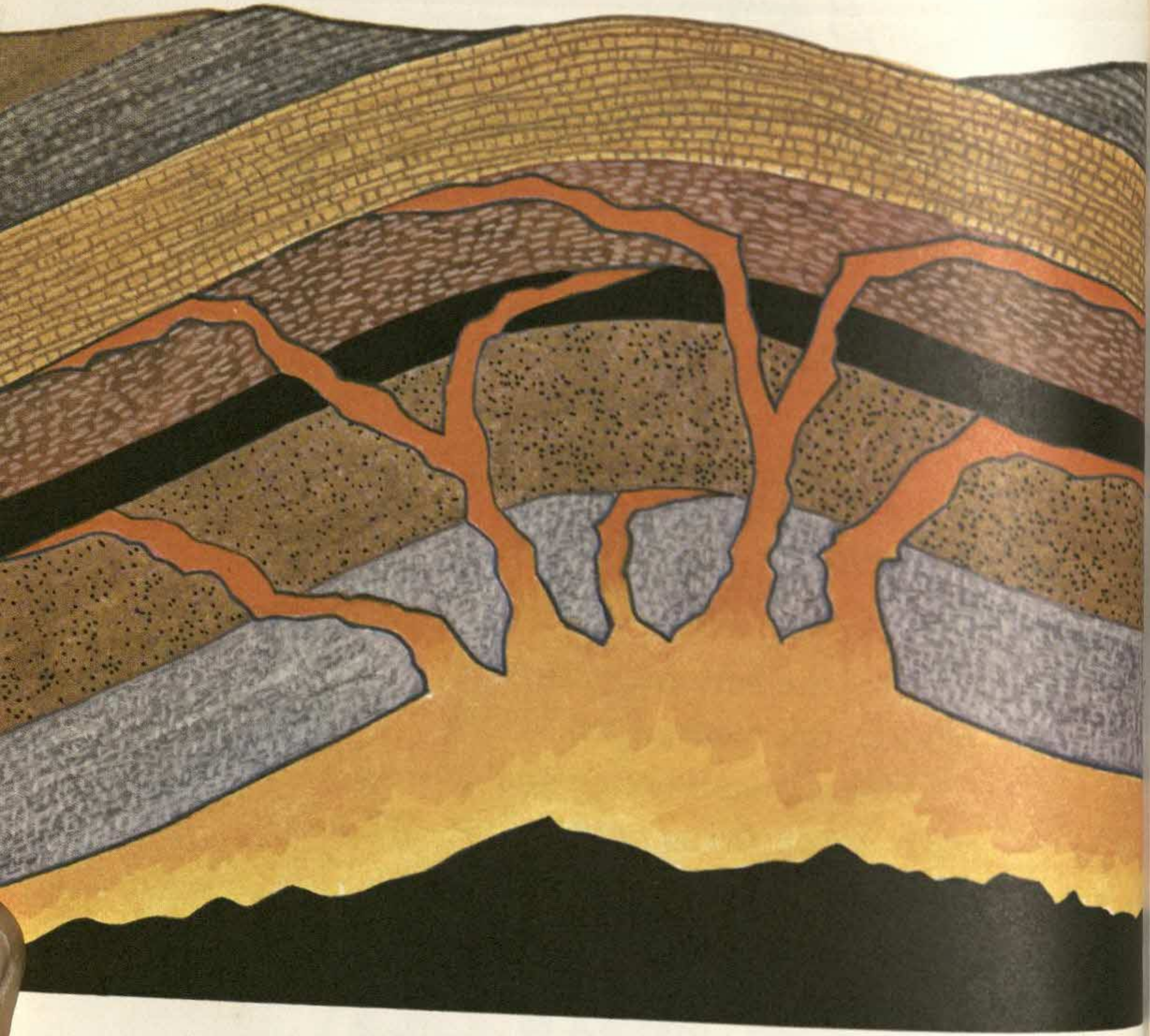
OBSERVE

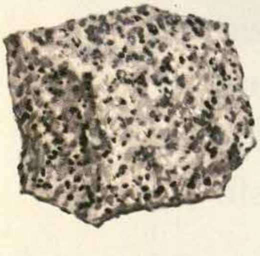
Take a partly-used tube of toothpaste. Roll up the bottom of the tube. What happens to the toothpaste? Why?

Make a small hole in the side of the tube with a pin. Press on the tube. What happens? Why?

The magma is like toothpaste. It can be squeezed between the layers of rocks. It can be pushed through an opening.

Make a cone from a sheet of paper. Place it over the open end of the toothpaste tube. Cut the point off the cone. Squeeze the tube. What happens? What happens as you keep squeezing the tube? Stop. What happens? How did this toothpaste act like magma?

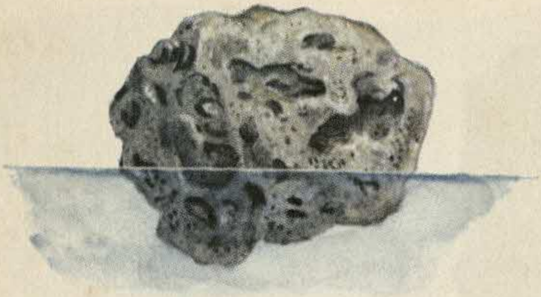


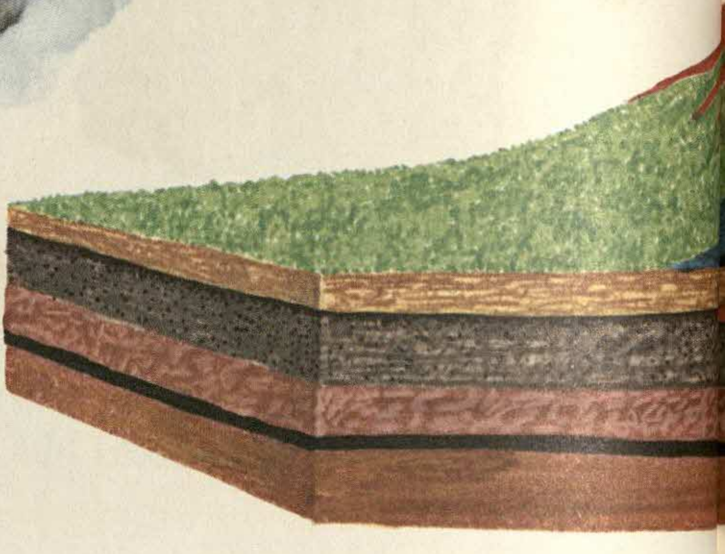


Some igneous rocks are made under the ground.

Some magma forces its way into spaces between layers of rock. It cools and hardens under the earth. It forms an igneous rock called granite (GRAN-it).

All these rocks were probably formed from magma that cooled under the ground. Have you found rocks like these?





Not all igneous rocks are made under the ground.

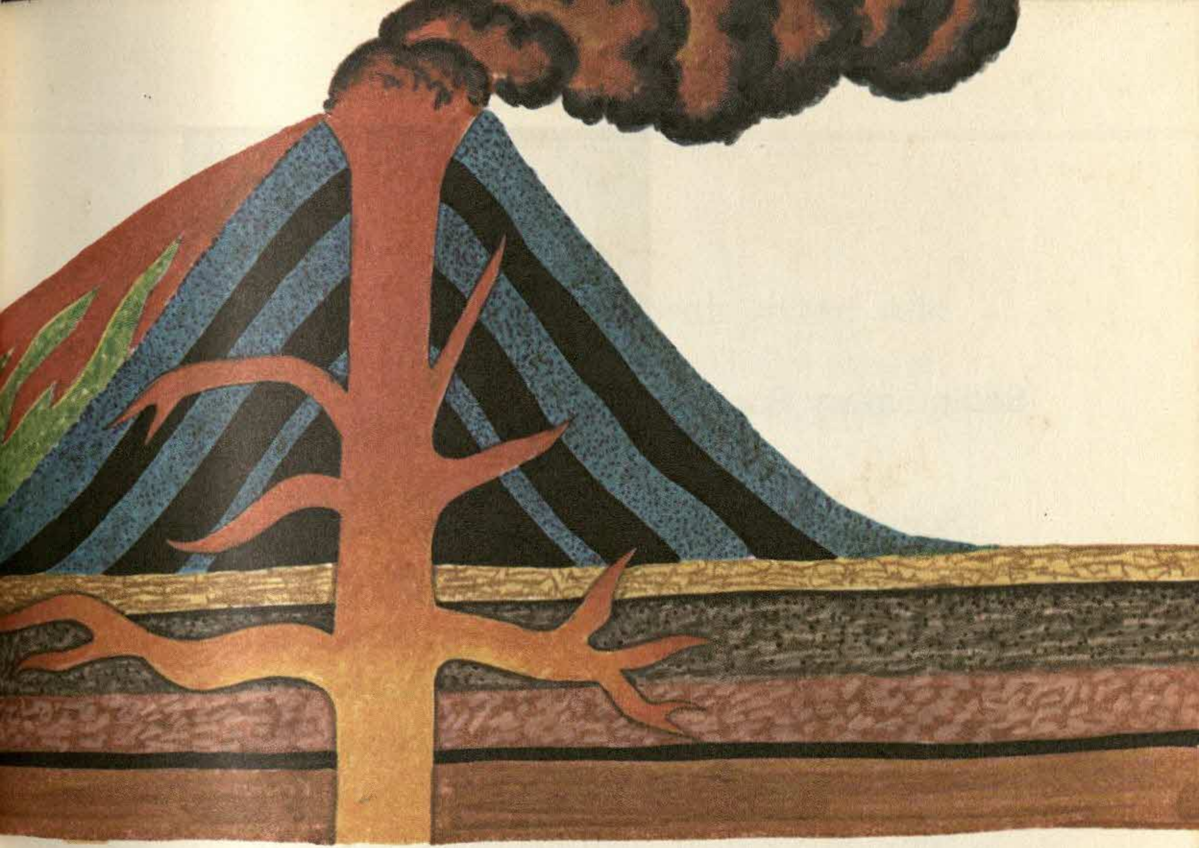
The magma that reaches the surface of the earth and flows outside is called lava (LAV-uh). Lava may form three kinds of rock.

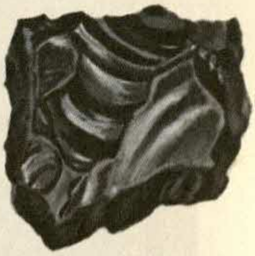
Sometimes lava spills out of the earth so quickly that it is foamy with air bubbles. Pumice (PUM-iss) is a kind of rock which is made from this kind of foam.

Pumice is soft.

Try to obtain a piece of this rock.

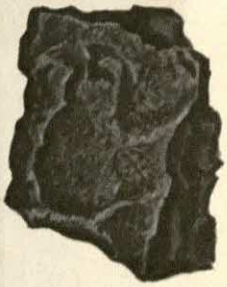
How does it feel?





Sometimes lava pours out slowly like tar. If this lava cools quickly, it forms a rock called obsidian (ub-SID-ee-un).

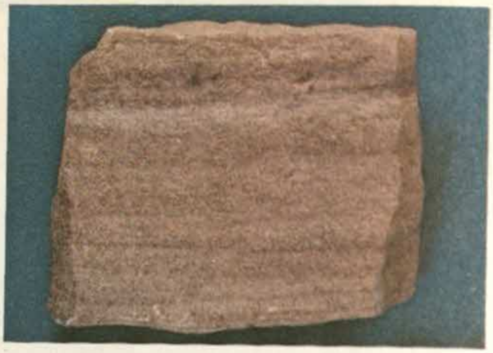
Sometimes lava pours out slowly. The lava cools and hardens slowly. It forms a rock called basalt (buh-SAWLT).



DESCRIBE

How are these rocks different?
How are they alike?

Sandstone



Sedimentary Rocks

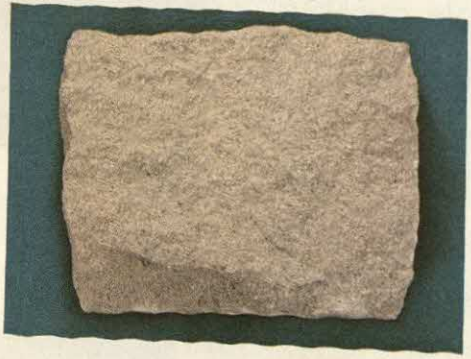
Some kinds of rock are not made from melted rock.

Some rocks are made under water.

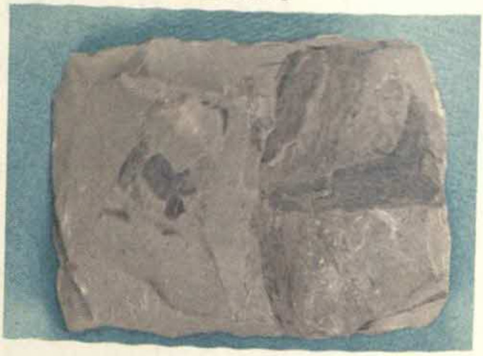
They are made from small pieces of shell, sand, and tiny rocks all stuck together.

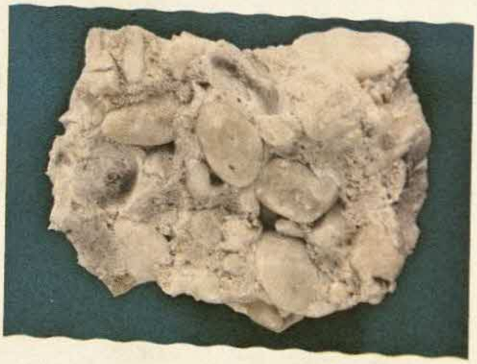
They are called sedimentary (*sed*-ih-MEN-tuh-ree) rocks.

Limestone



Shale





Conglomerate

How are sedimentary rocks made?

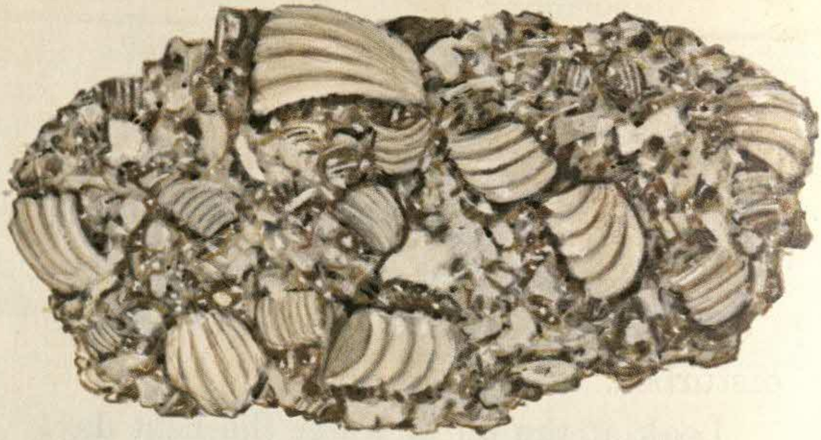
ACTIVITY

Half fill a glass jar with water. Add sand, gravel, and some soil. Shake the jar. Put the jar on a table where it will not be disturbed.

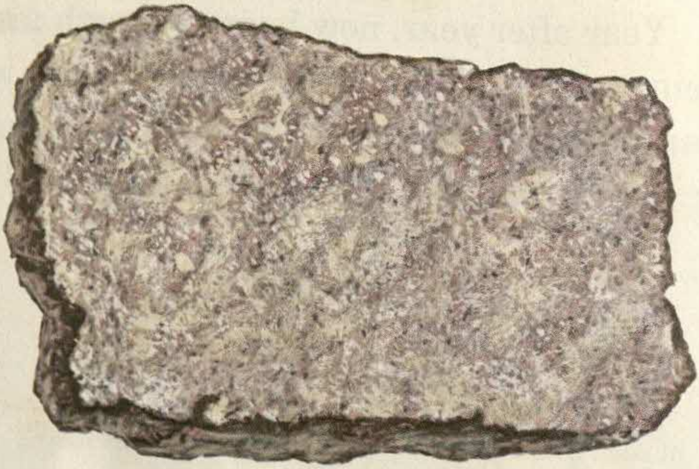
Look at the jar of water the next day. What happened? Why? What is happening at the bottom of the oceans?

Put your hand on your desk and lay a book on top of it. What do you feel? Add another book and then another. How does your hand feel now?

Year after year, new layers of earth are being added to the older layers. What is happening to the layers of earth that are being buried under layers of mud and sand?



Limestone is a rock made from the shells and skeletons of small animals that lived in the water a long time ago.



Sometimes limestone is worn smooth. It is not so easy to see the shells.

Is limestone always the same color?

How can you tell limestone from other rocks?

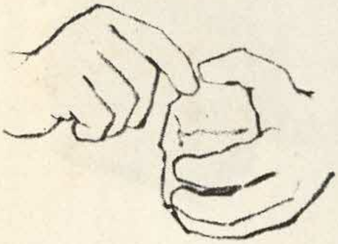
ACTIVITY

Put a piece of limestone in a dish. Put two other rocks in two other dishes.

Pour vinegar on each rock. What happens?

Scratch each rock with a penny. What happens?

Is limestone hard or soft?

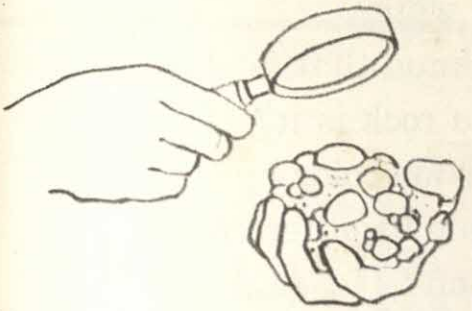


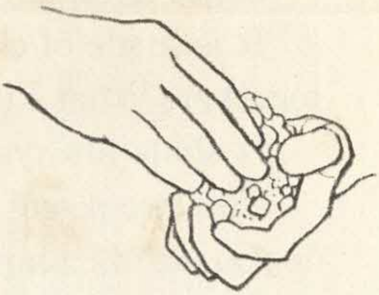
Sandstone is made under water.

It is made of tiny grains of sand stuck together. It is a sedimentary rock.

Break a piece of sandstone. What do you see? How does it feel?

Is sandstone the same color inside?





Conglomerate (kun-GLOM-eh-rit) is made under water.

It is made of stones and pebbles stuck together. It is a sedimentary rock.

Break a piece of conglomerate. What do you see? How does it feel?

Shale is made under water.

It is made of clay or mud that is stuck together. What kind of a rock is it?

Is shale always the same color?

Rub two pieces of shale together. What do you see? Is it hard or soft?

Do you have any sedimentary rocks in your collection?

ACTIVITY

You can make three kinds of rock. In a pint carton, mix two or three teaspoonfuls of cement with some wet sand. Label it A. In another, mix the same amount of cement with wet mud. Label it B. In a third, mix some lime plaster with water. Label it C.

In the earth, the weight of the top layers squeezes the particles of mud or sand together.

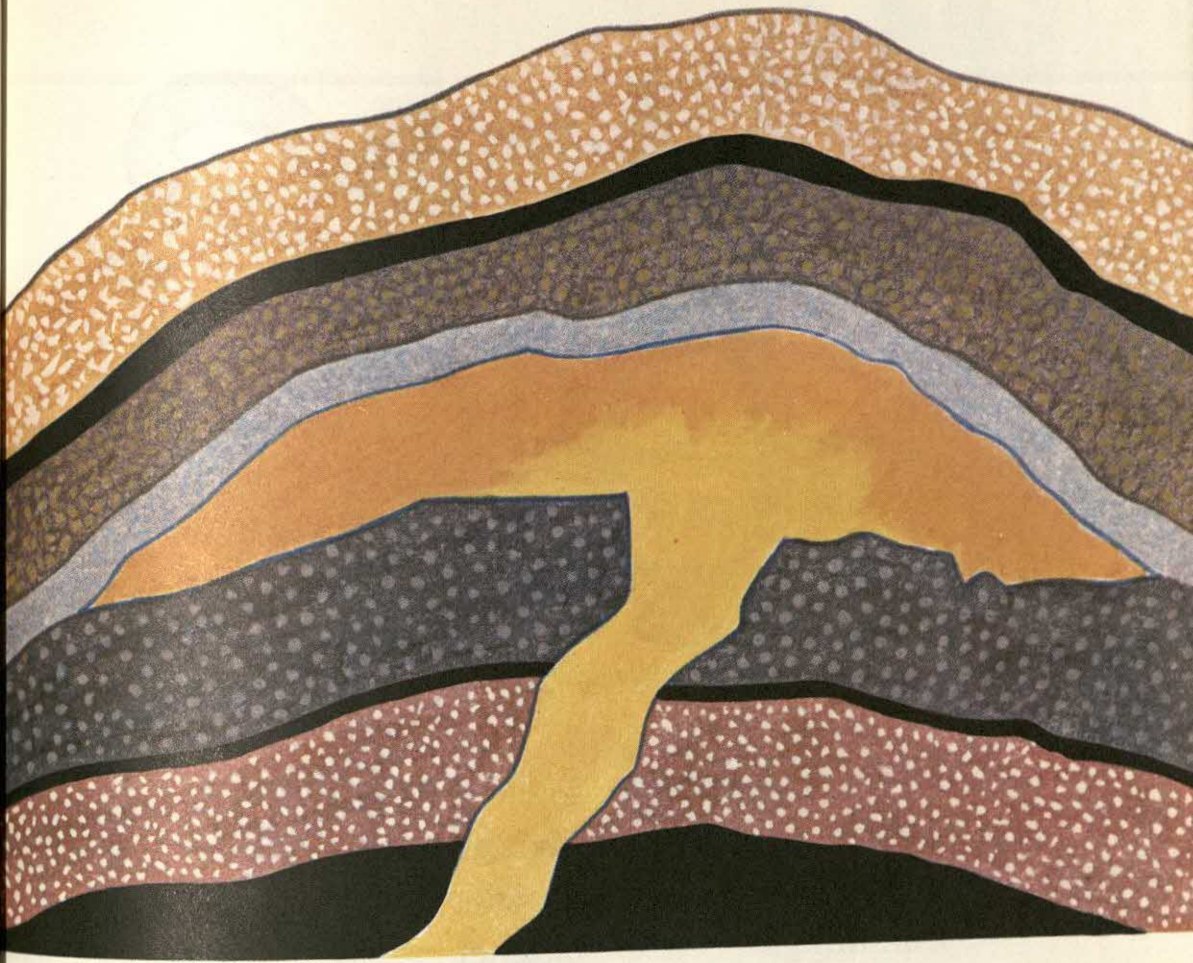
Look at the rock models. A is like sandstone; B is like shale; C is like limestone.

Metamorphic Rocks

Some rocks are made from other rocks. They are called metamorphic (*met*-uh-MOHR-fik) rocks.

DESCRIBE

Open your book and hold it with your left hand. Push on the edges of the pages with your right hand. What happens to the pages in the middle?



In the long, long time that it took to form the earth, sedimentary rocks were often pushed and pulled. The layers were no longer straight. Spaces were sometimes left between layers.

Magma sometimes pushed into these spaces. It squeezed the sedimentary rock around it. The sedimentary rock changed. A new kind of rock was formed.

ACTIVITY

How can rocks be changed?

For this activity you will need:

iron filings	magnet
powdered sulphur	test tube and holder

What color is the sulphur?

Put the magnet near the iron filings.

What happens?

Mix the iron filings and sulphur together. Can you see the sulphur? Hold the magnet close to the mixture. What happens? Pull the magnet through the mixture.

What happens?

ACTIVITY

Mix the sulphur and iron filings again. Put the mixture into the test tube. Your teacher will heat the mixture in the test tube. Watch what happens. Do you see any changes? Keep heating until no sulphur can be seen.

Put the end of the test tube into a jar of cold water. What happens? If the test tube does not break, cover it with a cloth and hit it. What color is the material in the broken test tube? Test the material with a magnet.

You have made a new substance. This is like what happened thousands and thousands of years ago to some of the sedimentary rocks. Some igneous rocks were changed too.

COMPARE

Slate is a metamorphic rock. It was made from shale. Your blackboard may be made of slate.

How do slate and shale differ?
Which is harder?
How are they alike?

Marble is a metamorphic rock. It was made from limestone. How could you tell?

REVIEW

What happened when you poured vinegar on limestone? What happens when you pour vinegar on marble?

Which is harder?

COMPARE

Look at some pieces of limestone and marble under a magnifying glass. How do they differ?

Schist (SHIST) is a metamorphic rock. It was made from conglomerate.

Gneiss (NYSS) is a metamorphic rock. It was made from granite.

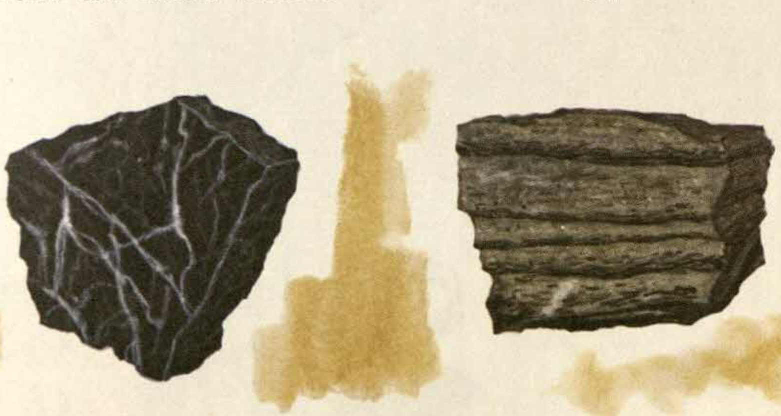
How is gneiss different from the other rocks?

Many metamorphic rocks are marked by light and dark bands. What causes these bands?

ACTIVITY

Examine a piece of fresh bread. How thick is it?

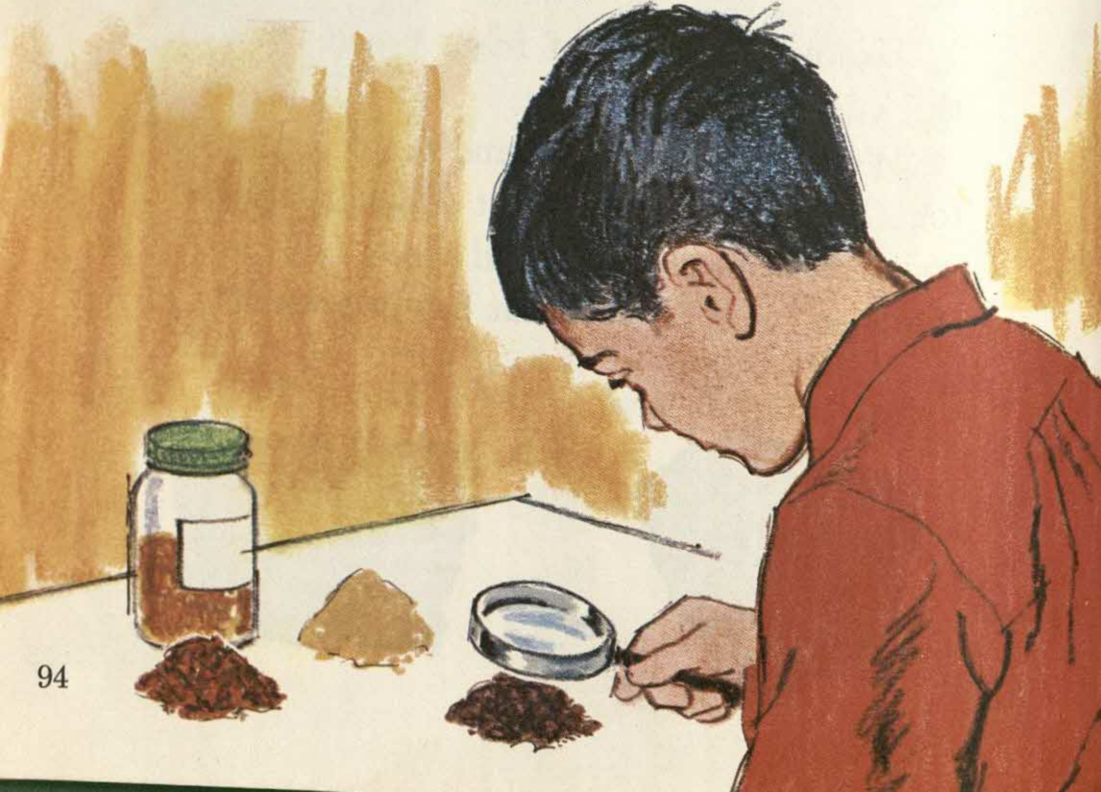
Wrap slices of white and brown bread together in wax paper. Put several heavy books on the wrapped bread slices. Look at them an hour later. What has happened?



ACTIVITY

Rub two pieces of sandstone together over a piece of paper. Do the same using pieces of limestone, granite, and slate. Feel the dust on the papers. What difference do you notice when you feel them?

Collect some samples of different kinds of soil, including sand. Feel the soil between your fingers. Smell it. Moisten a little of the soil and feel it. Look at the soil with your magnifying glass. Compare the rock dust with the soil. How do you think some soil was formed?

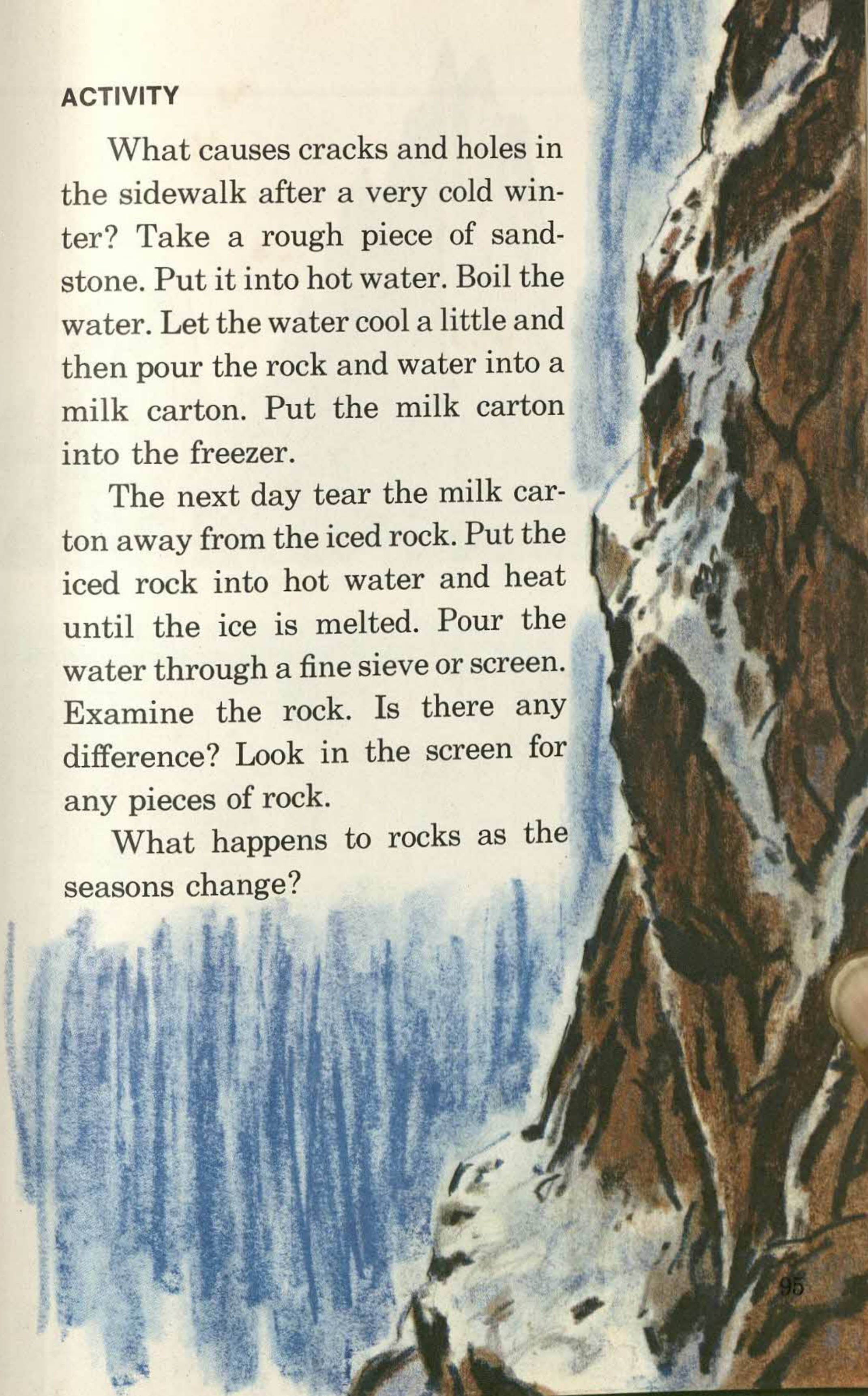


ACTIVITY

What causes cracks and holes in the sidewalk after a very cold winter? Take a rough piece of sandstone. Put it into hot water. Boil the water. Let the water cool a little and then pour the rock and water into a milk carton. Put the milk carton into the freezer.

The next day tear the milk carton away from the iced rock. Put the iced rock into hot water and heat until the ice is melted. Pour the water through a fine sieve or screen. Examine the rock. Is there any difference? Look in the screen for any pieces of rock.

What happens to rocks as the seasons change?



REVIEW

How do rocks wear away?

Why are pebbles on the seashore so smooth?

When people build roads, cut through hills or make tunnels, how do they break the rocks?

Have you ever been out in a hard wind?

Did you feel any soil in the air?

The Grand Canyon is one mile deep and about ten miles wide. It is getting deeper and wider every year. Why?

Small pieces of rock mix with the remains of plants and animals to make the topsoil in which plants grow. The change from rock to soil takes a long, long time. How deep is the topsoil near your home?

Are there different kinds of soil?

COLLECT

Collect different kinds of soil in glass containers.

What kinds of soil have you collected? Check the chart below.

CLAY		fine-grained, light in color, sticky when wet
GRAVEL		coarse, contains pebbles
SANDY		gritty, contains grains of sand which can be seen with a magnifying glass
LOAM		mixture of sand and clay
HUMUS		dark and loose, contains decayed plant and animal matter

Do plants grow better in some soils than in others?

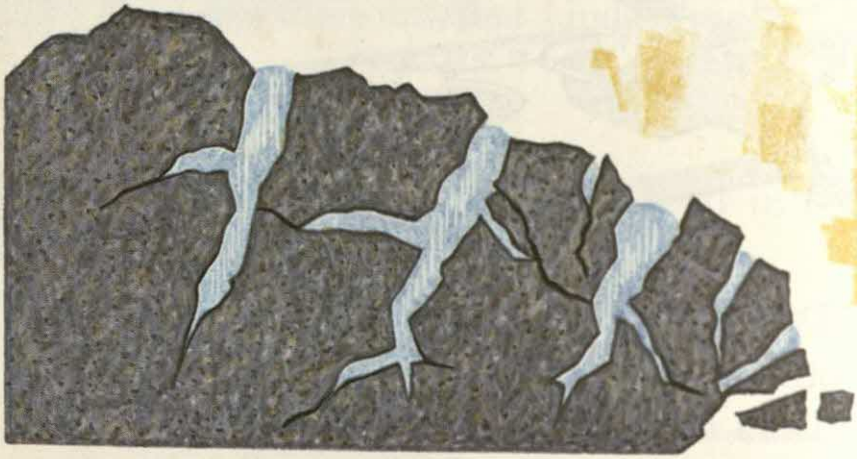
Take five milk cartons. Fill each with one kind of soil. Punch a few small holes in the bottom of the carton and put each on a small plate. Pour water into the plate. In about a half hour, feel the top of the soil to find if it is moist.

Scatter some grass seed over the top of the wet soil. Put the cartons in a sunny place. Keep the soil moist by putting water into the plate.

In which do you think grass will grow? In which will the grass grow for the longest time? Use scissors to keep the grass trimmed to about two inches. Keep a record of how your grass grows.

THINK

How does the freezing and melting of water break rocks?



Some sandstones are light in color and some are dark. Others are red. Can you explain the differences?

Are hard rocks usually heavier than soft rocks? Are light-colored rocks usually heavier than dark-colored ones? Try to explain your answers.

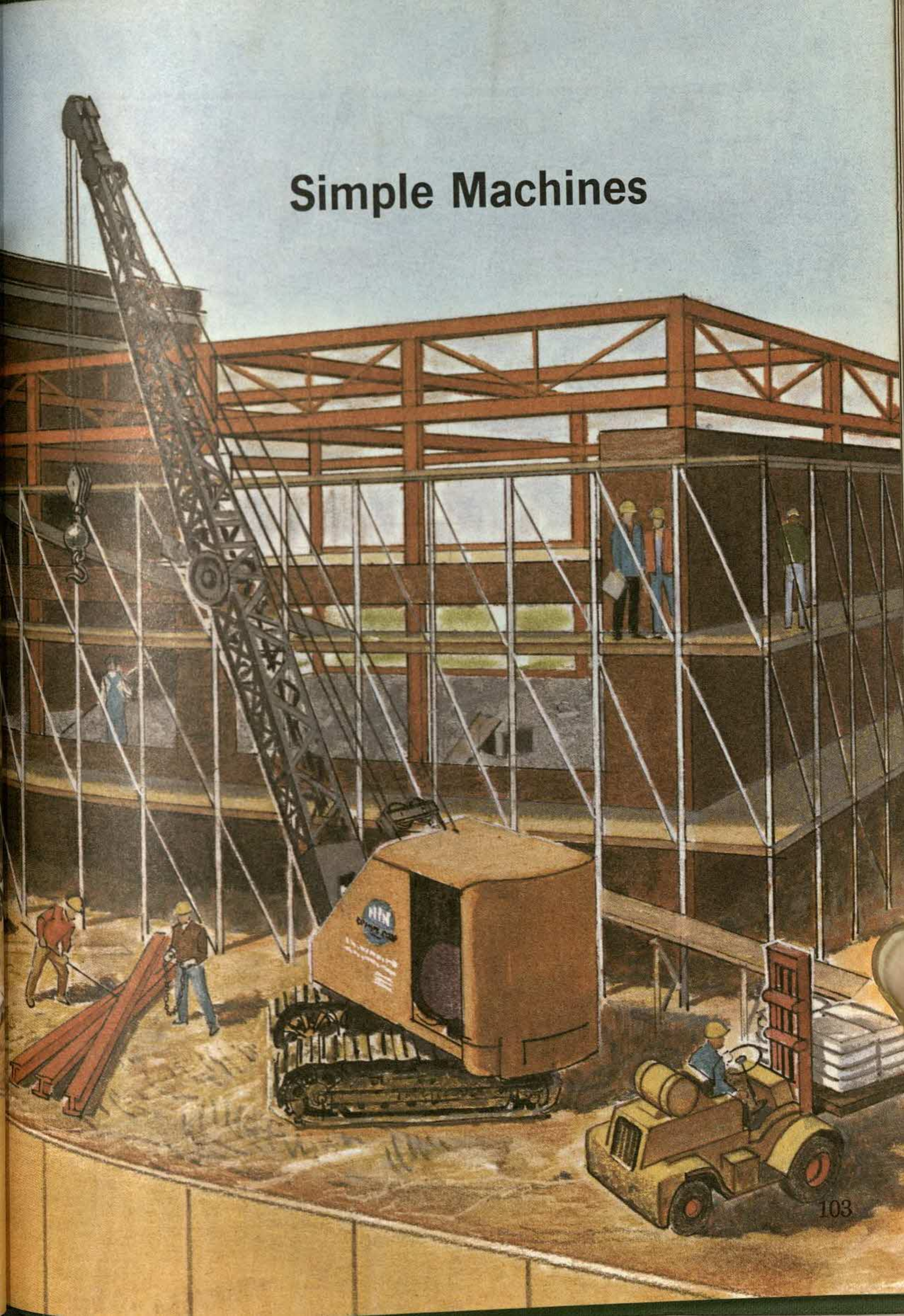
PROJECTS

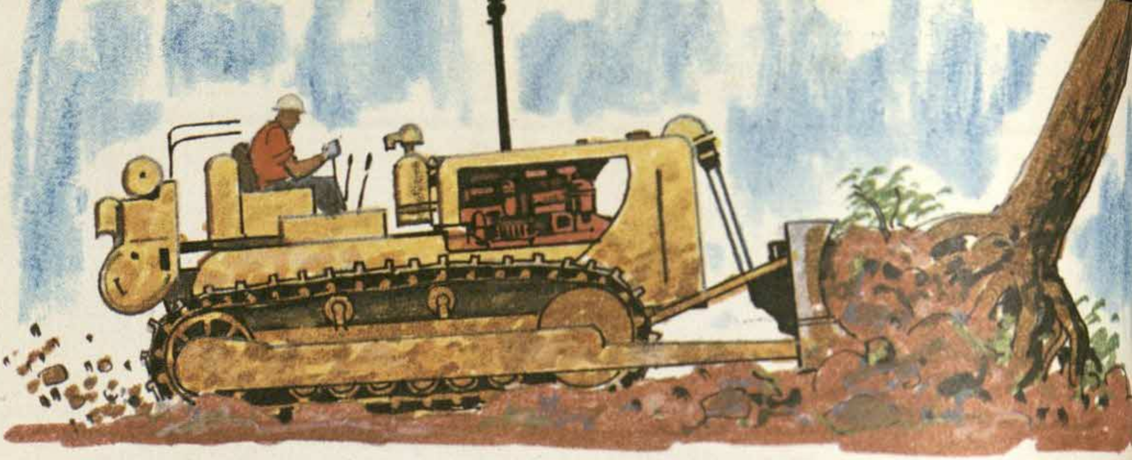
Collect as many kinds of rocks as you can. Try to classify them according to the way in which they were formed.

Take a mixture of rocks and sands of various sizes and pour it into a jar of water. Shake the mixture and allow it to settle. What do you observe? How might your observations explain what you would see close to the shore line or along a river bed?

OL BUS

Simple Machines





What Is A Machine?

Machines! How many machines can you name? How do machines help us? Why do we need machines?

OBSERVE

Look at the chart below. In which column would you put each machine you named?

Look carefully at the title of each column. What two words do you find in each title?

Work is done when an object is pushed or pulled a distance. How do the machines you named help us to do work?

Moves heavy objects	Moves objects faster	Moves objects in another direction

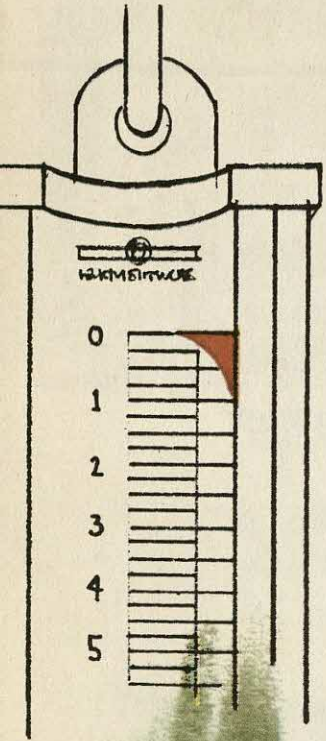
ACTIVITY

Take five copies of the same book.

Pick up one book from the table. Lift it to your shoulder. You have worked. You have moved an object through a distance.

Pick up all five books. Lift them to your shoulder. Why was lifting five books harder work than lifting one?

What was pulling the books down as you lifted them up?



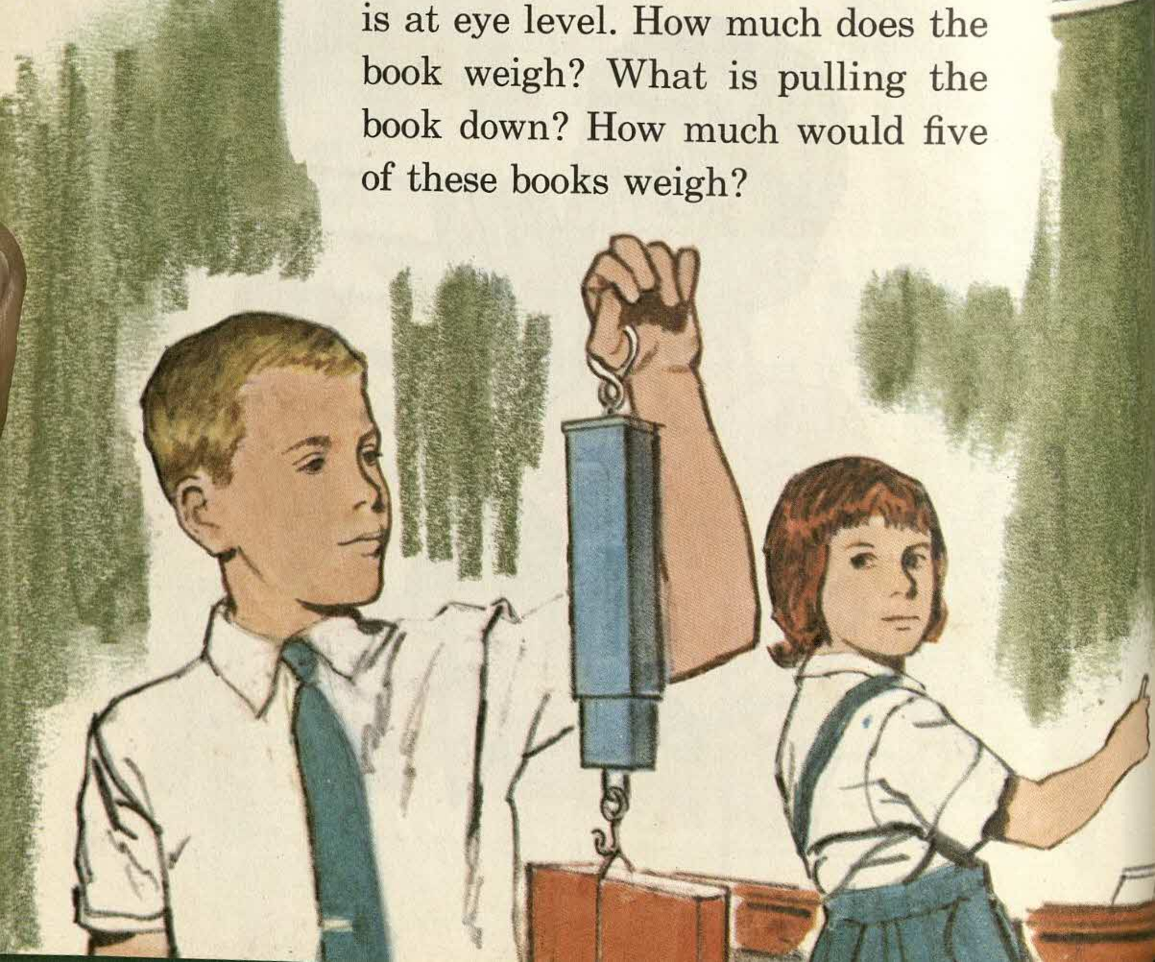
The weight of an object is the measure of the pull of gravity.

ACTIVITY

Take a spring scale. Examine it. What happens to the metal spring when it is pulled?

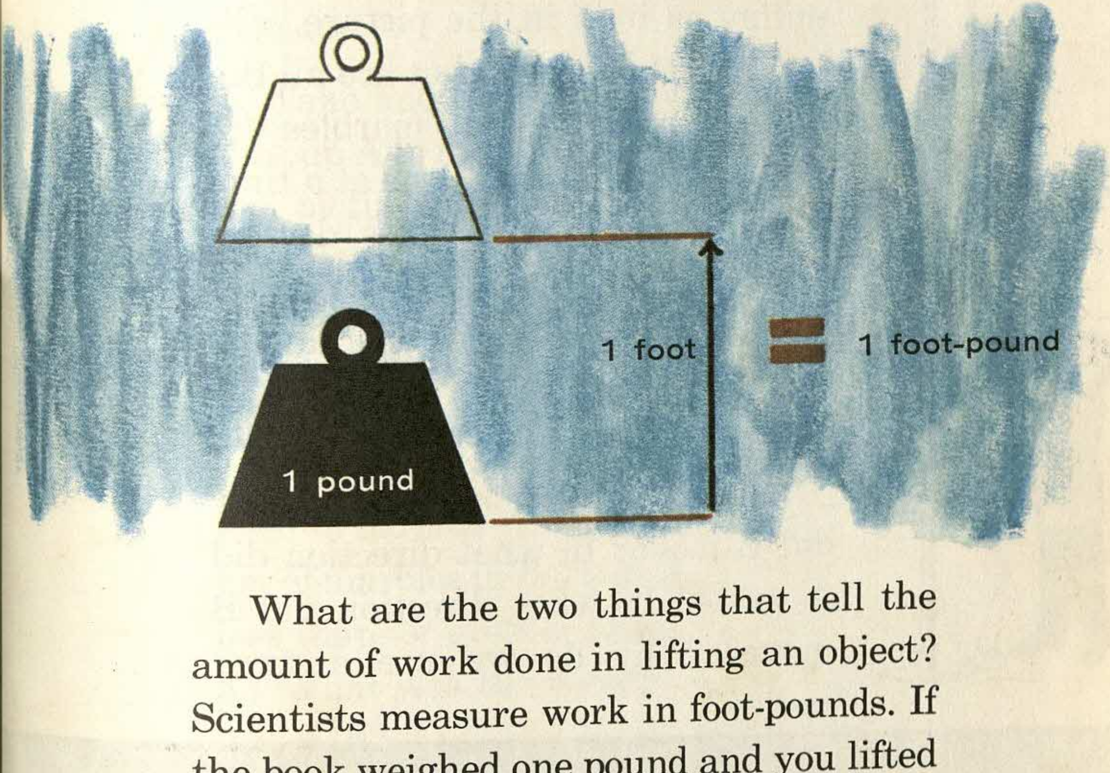
Look at the picture. How do you read each of the marks?

Hang one book from the hook of the spring scale. Put your finger in the metal ring at the top and hold the spring scale so that the pointer is at eye level. How much does the book weigh? What is pulling the book down? How much would five of these books weigh?



Lower your book to the floor. Now raise the book up as high as the table. Keep the pointer of the spring scale at eye level. What does the scale read as you lift the book?

How high did you lift the book? Measure the distance with a yard stick.

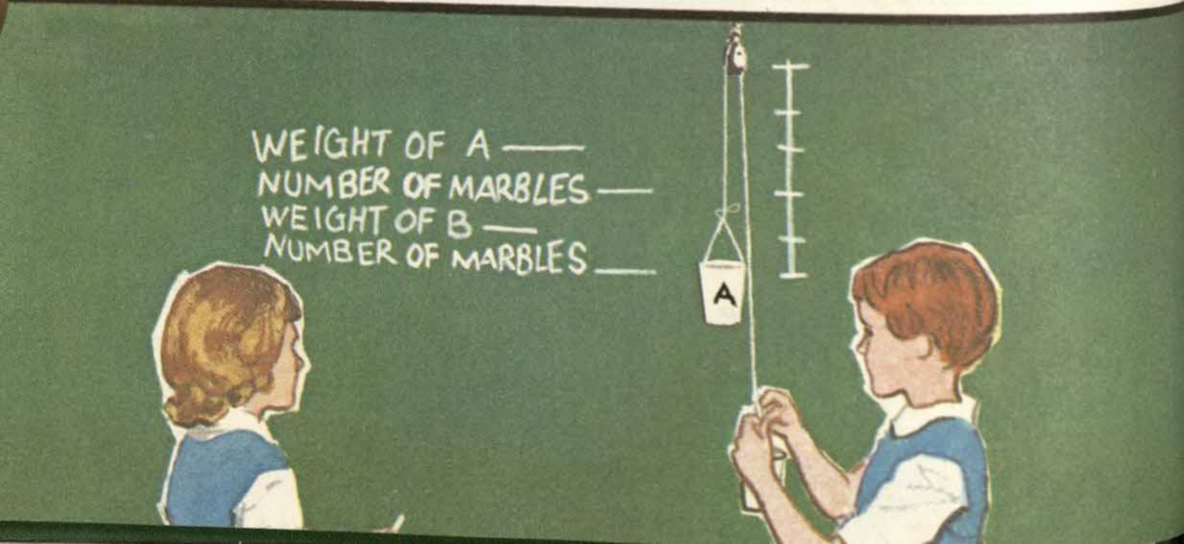


What are the two things that tell the amount of work done in lifting an object? Scientists measure work in foot-pounds. If the book weighed one pound and you lifted it one foot, you did one foot-pound of work. How much work would you do if you lifted one pound a distance of 3 feet? How much work would you do if you lifted 5 one-pound books a distance of 2 feet?

How is the boy raising the flag? How do you know that the boy is working? In what direction is the boy pulling? In what direction is the flag moving? How is the pulley helping the boy to do work?

Look at the picture and fix a pulley as it is in the picture. Fill cup A with marbles that are all the same size. How many marbles did you use? Add marbles one at a time to B. How many marbles do you need to move A? Is the number of marbles the same, greater than, or less than in A? What is the weight of A? of B?

How far did A move? How far did B move? In what direction did A move? In what direction did B move? Why do we use a fixed pulley?


WEIGHT OF A ——
NUMBER OF MARBLES ——
WEIGHT OF B ——
NUMBER OF MARBLES ——
A

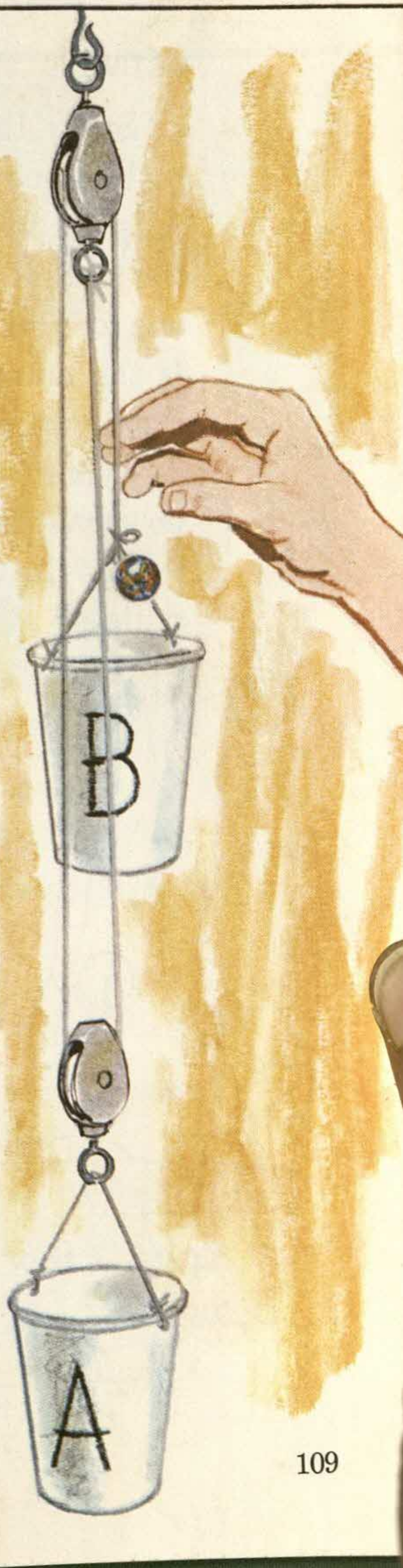
EXPLAIN

Take another pulley. Tie the cup A to its ring. Look at the picture to see how to string the two pulleys.

Fasten the empty cup B to the loose end of the string. Add marbles one at a time to B. How many marbles do you need to move A? Is the number of marbles in B the same, less than, or greater than in A? What was the weight of A? of B?

How far did A move? How far did B move? Move A one foot. How far did B move?

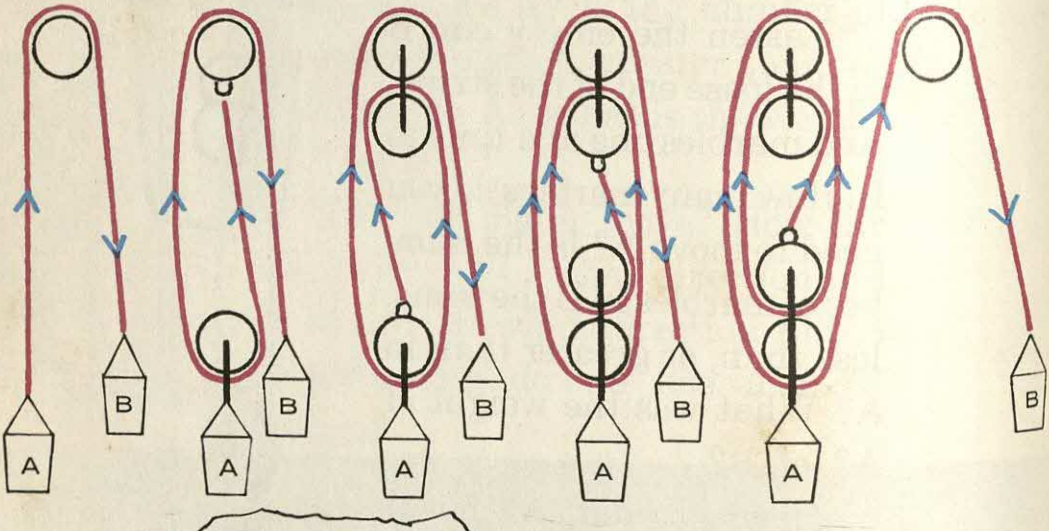
Why do we use fixed and movable pulleys?

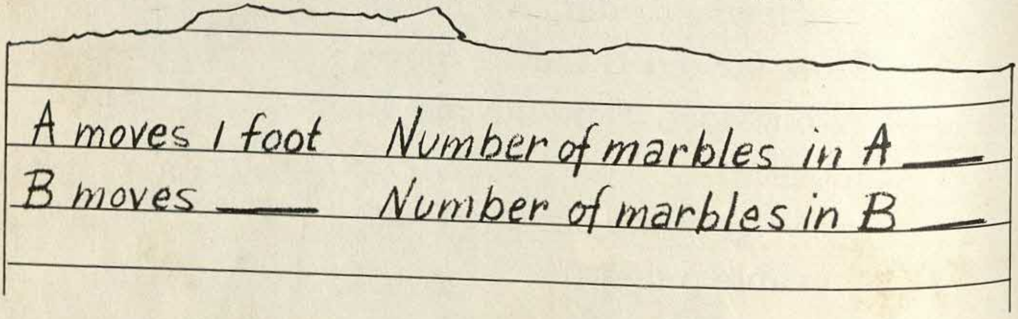


ACTIVITY

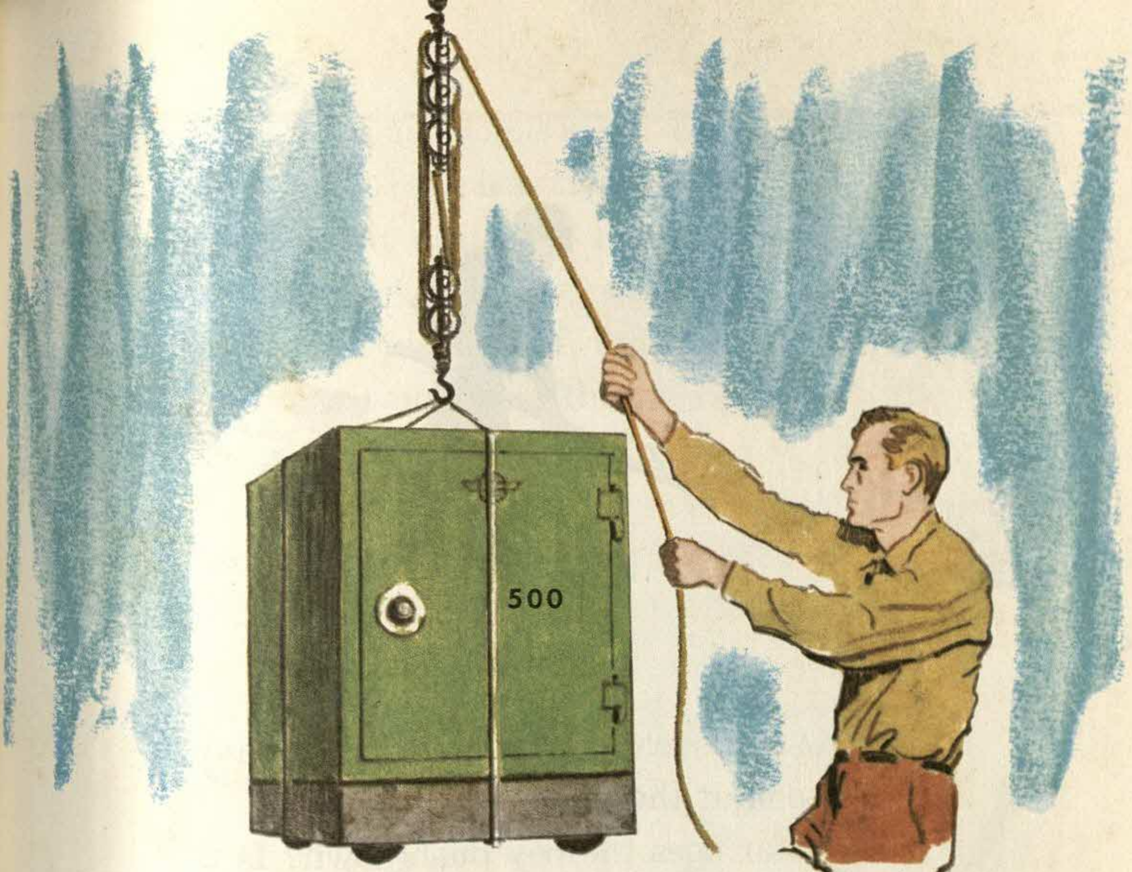
Study the diagrams below. String the pulleys and use your cups of marbles. Cup A is the weight you are lifting. Cup B is the force that is pulling the weight. Lift A one foot each time. How far does B move? Is the number of marbles in B the same, greater than, or less than in A?

What can you discover about how pulleys make work easier? Do pulleys do work for us? In what other ways could you fix pulleys?




A moves 1 foot Number of marbles in A ___

B moves ___ Number of marbles in B ___

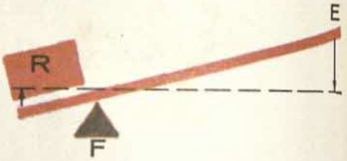


When more than one pulley is used, the pulleys are called a block and tackle. The pulley is the block. The rope or chain is the tackle. Look at the picture.

OBSERVE

How much does the safe weigh? How can one man lift so much weight?

How much work is done when the safe is lifted one foot? The man is pulling with a force of 100 pounds. How much rope will he have to pull to raise the safe one foot? How do pulleys help us to do work?



How can such a little boy lift a heavy rock? Look at the diagram.

How far does the boy push down? Is it the same distance as the rock moves? Greater? Less? A smaller force can be used because it is moved through a greater distance. How do pulleys make work easier?

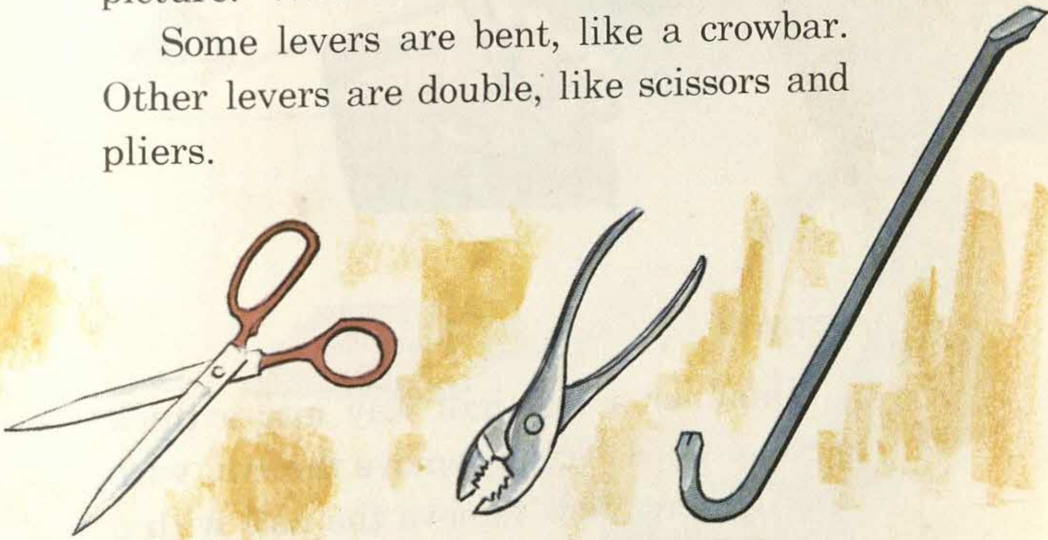
The boy is using the branch as a lever. A lever is a rigid bar fixed at one point. The point where the bar is fixed is called the fulcrum (FUHL-kruhm). The pull or push that is used is called the effort (E). The weight that the boy is lifting is called the resistance (R).

Where is the fulcrum in the lever the boy is using? The effort? The resistance?

Scientists sometimes use shorthand symbols to take less time and to make their work a bit easier. A letter may be used as a symbol for a number name. For example, instead of writing Effort, the scientist would use the letter E. For Resistance, he would use an R.

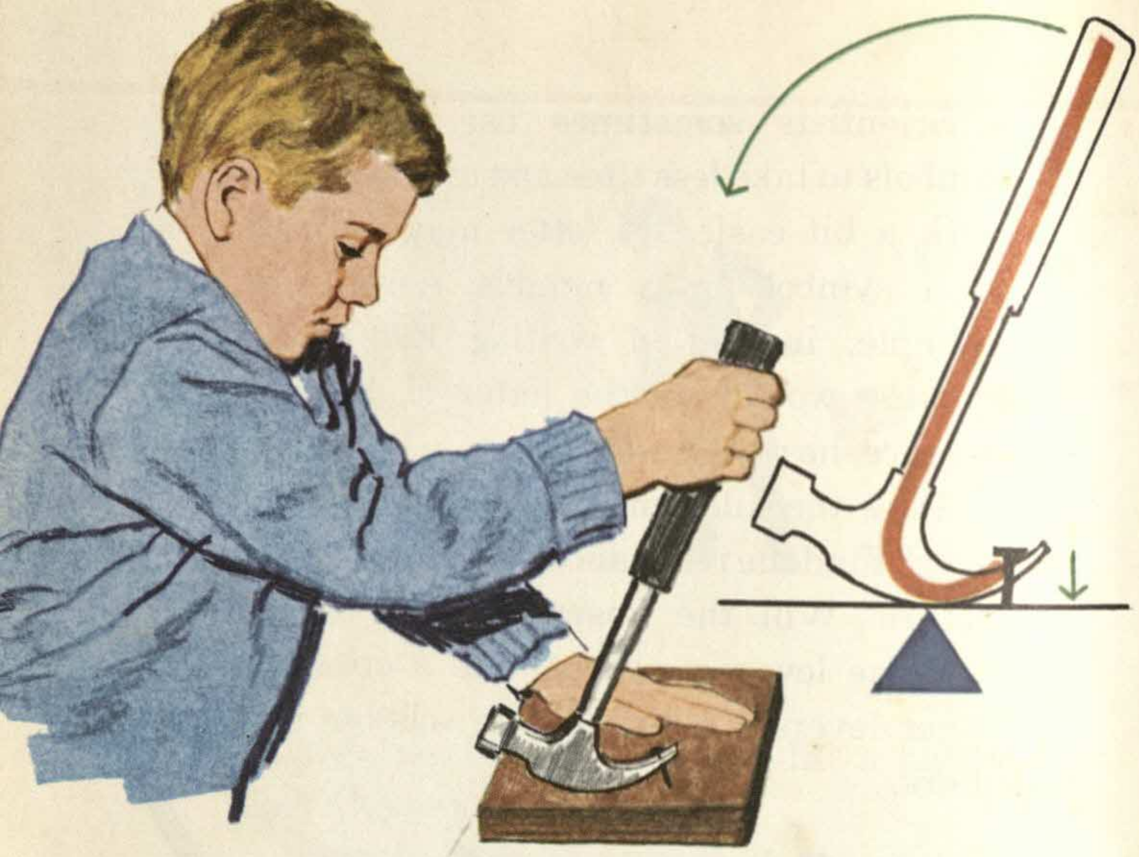
Does the fulcrum move in this type of lever? Find the resistance and effort in each picture. Will the answers be numbers?

Some levers are bent, like a crowbar. Other levers are double, like scissors and pliers.



OBSERVE

Look at the pair of scissors. Each blade is a lever. Where is the fulcrum? Does the fulcrum move? Does the fulcrum move on any lever? Find the resistance and effort for each of the double levers.



ACTIVITY

Hammer a nail half way into a thick piece of wood. Try to remove the nail with your fingers. Now remove the nail with a hammer as shown in the picture.

Why is a hammer used this way called a lever? Where is the fulcrum?

Compare the hammer with the diagram.

How would you show that a hammer works better when the effort is located at the end of the hammer?

ACTIVITY

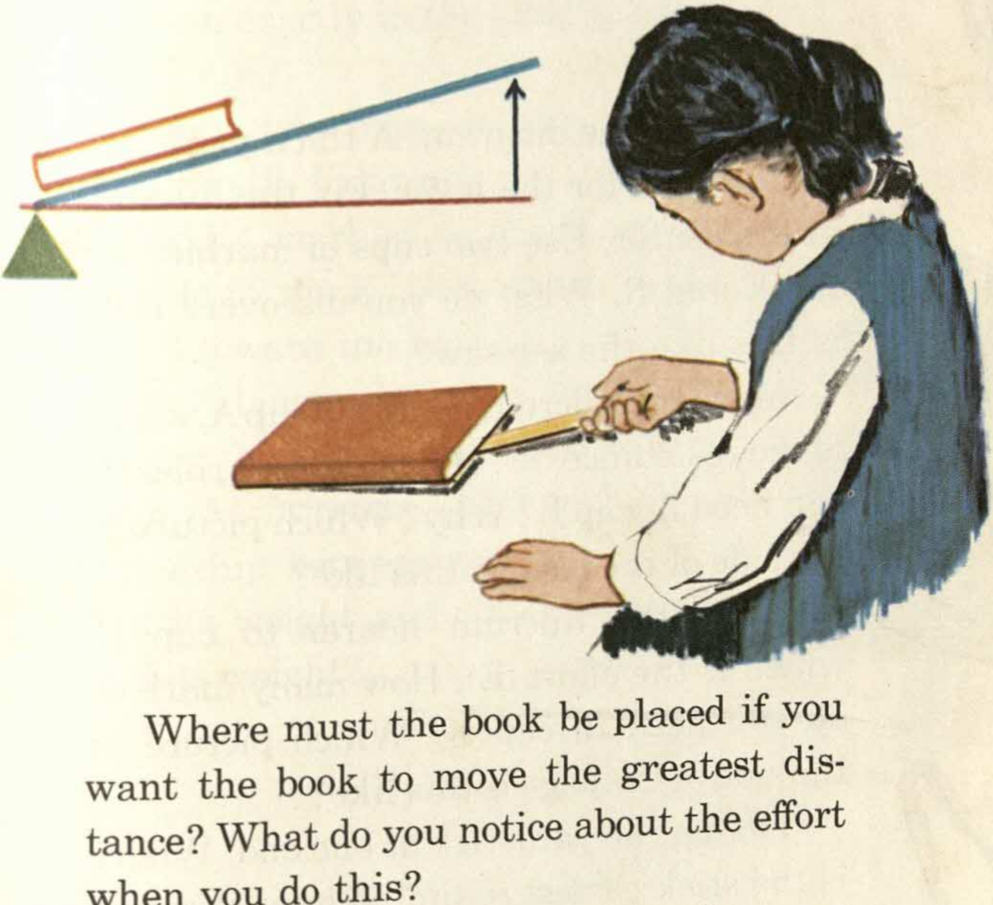
Place a book on a ruler as shown in the picture.

Lift the ruler to raise the book.

Does the fulcrum move?

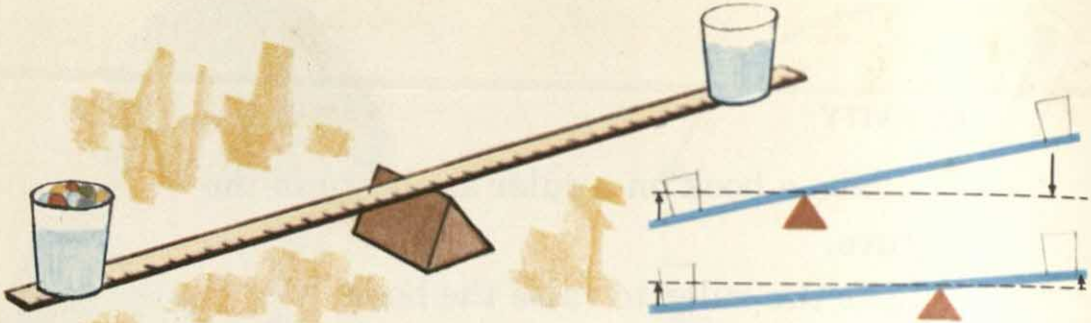
Move the book closer to the effort force.

Lift the book again. What do you notice?



Where must the book be placed if you want the book to move the greatest distance? What do you notice about the effort when you do this?

How far does the book move when you wish to use the least amount of effort?

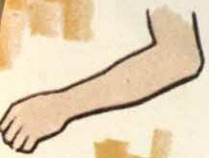


Let's explore the different types of levers to see how they work.

ACTIVITY

Look at the diagram. A thick yardstick can be used for the lever. Fix the fulcrum at the center. Use two cups of marbles for the E and R. What do you discover? How is this like the see-saw?

Move the fulcrum nearer to cup A, which is the resistance (R). How many marbles do you need in cup B? Why? Which picture at the side of the page is this like?



Move the fulcrum nearer to cup B, which is the effort (E). How many marbles do you need in cup B? Which picture at the side of the page is this like?

Fasten the yardstick at one end. Where is the stick easiest to lift? Why is it easier to lift at the end than at the center? Which picture at the side of the page is this like?

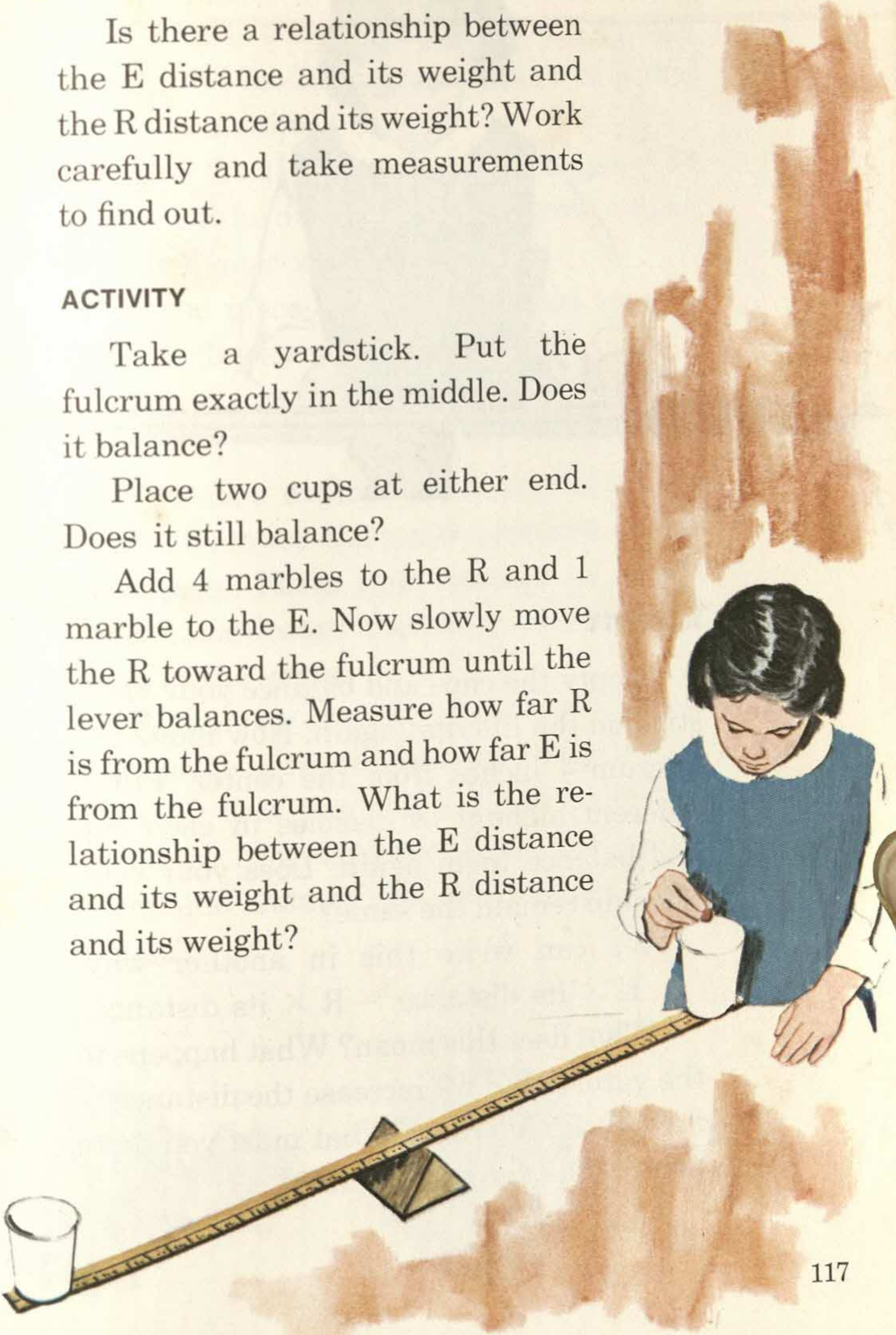
Is there a relationship between the E distance and its weight and the R distance and its weight? Work carefully and take measurements to find out.

ACTIVITY

Take a yardstick. Put the fulcrum exactly in the middle. Does it balance?

Place two cups at either end. Does it still balance?

Add 4 marbles to the R and 1 marble to the E. Now slowly move the R toward the fulcrum until the lever balances. Measure how far R is from the fulcrum and how far E is from the fulcrum. What is the relationship between the E distance and its weight and the R distance and its weight?



ACTIVITY

Empty the cups and balance your yardstick on the fulcrum again. Now move the fulcrum 4 inches from the center. Put a different amount of marbles in each cup and balance them again. Does your relationship remain the same?

We can write this in another way.

E × its distance = R × its distance

What does this mean? What happens to the yardstick if we increase the distance of R from the fulcrum? What must you do to balance the yardstick again?

A gear is a toothed wheel. It can change power and motion from one part of a machine to another.

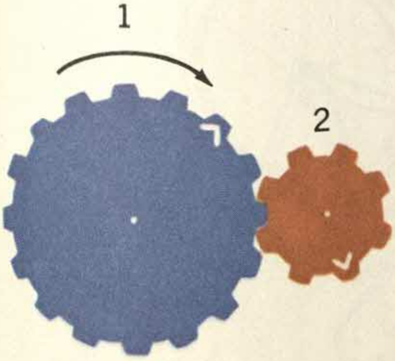
Look at the gears below. If gear #1 moves in the direction of the arrow, which way will gear #2 move?

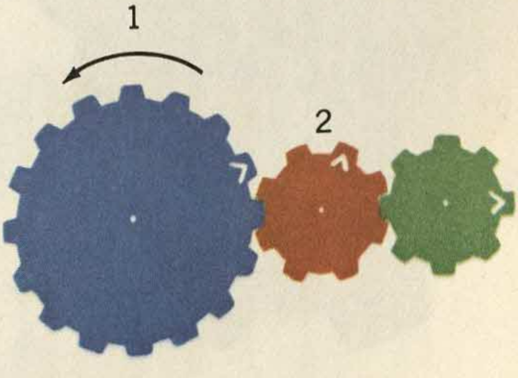
If you place another gear next to gear #2, which way will it move?

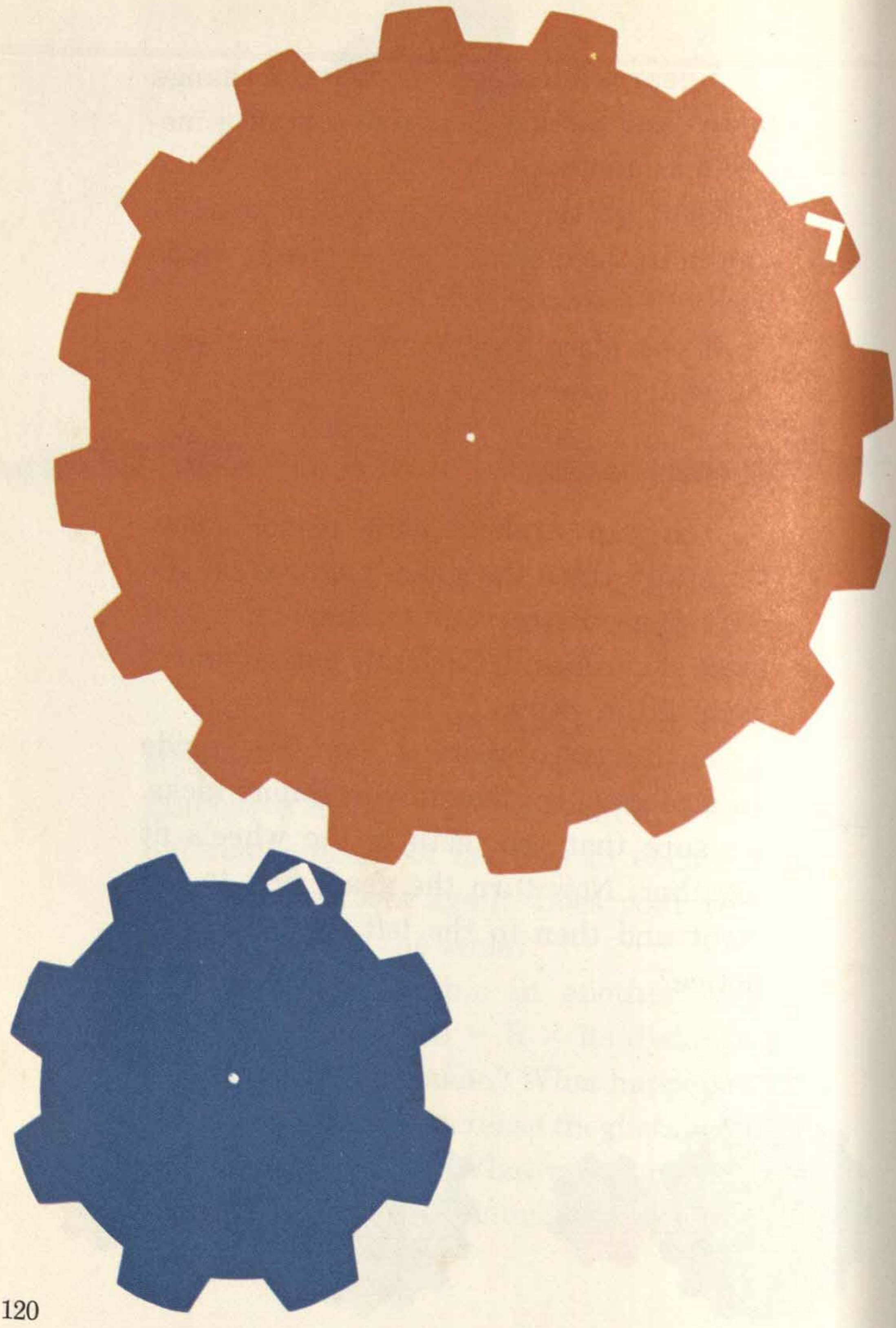
ACTIVITY

You can explore some model gears. Carefully trace the gears pictured on the next page. Paste your tracings on a stiff piece of cardboard. Carefully cut out two of each of the gears.

Fasten two or more of them side by side on a piece of cardboard with thumb tacks. Be sure that the teeth of the wheels fit together. Now turn the gears first to the right and then to the left. What do you notice?







Turn the large gear around once. How many times did the small gear go around? Turn the small gear around once. How many times did the large gear go around?

If you wanted something to go faster, to which gear would you apply your effort?

Sometimes one gear turns another with a chain as on your bicycle. Turn a bicycle upside down and look at the gears. The large gear is attached to the pedals and the small gear is attached to the rear wheel. Push the pedal to turn the large gear around once. Does the smaller gear turn too? Does it turn at the same speed? When the large gear turns once, how many times does the smaller gear turn?

Look at your cardboard gears again. If you wanted something to move more slowly, to which gear would you apply the effort?

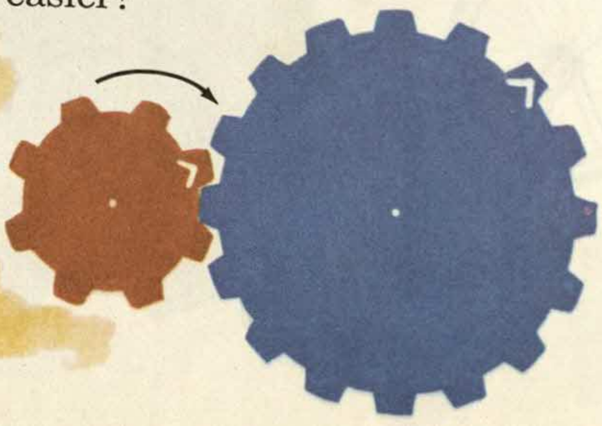
Arrange your cardboard gears in different ways. For example, if you turned the small gear in the direction of the arrow in the picture below, which way would the large gear turn? Would it turn faster or slower than the smaller gear?

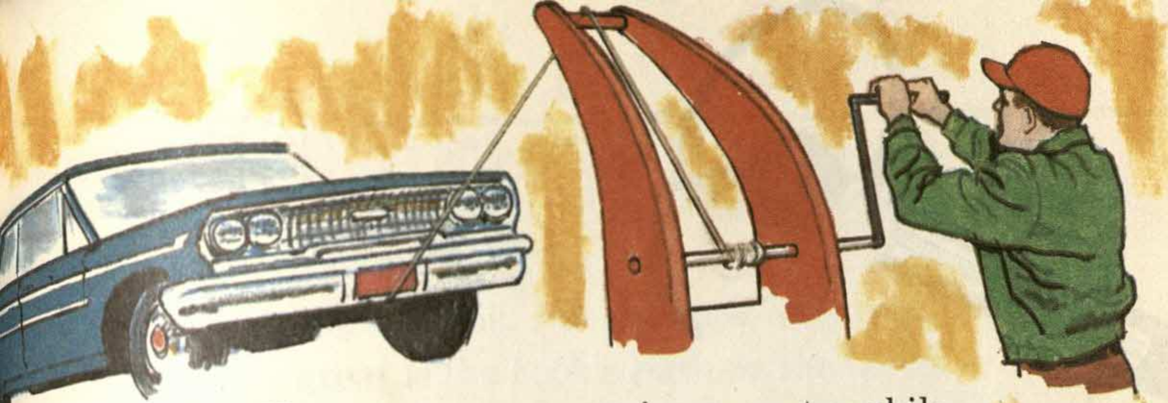
ACTIVITY

Arrange your gears this way. What happens to the larger gear? In what other ways could you arrange your gears?

Look at an egg beater. Find the large gear and the smaller gears. How does the direction of power change?

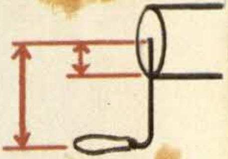
Put a crayon mark on one blade of the egg beater. Turn the large gear slowly. How many times do the blades turn when the large gear turns once? How are these gears arranged to change the direction of power? How do they turn the effort into more speed? How do they make work easier?





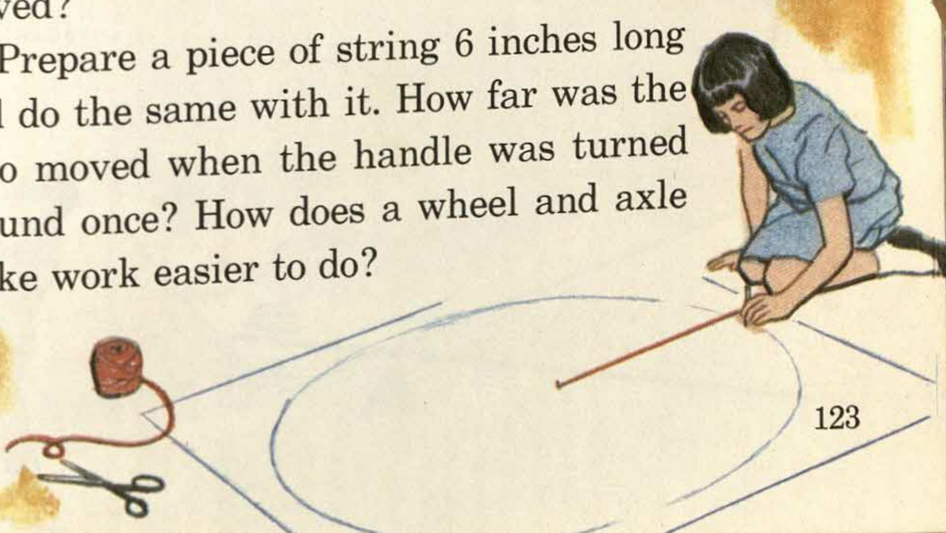
How can one man raise an automobile that weighs thousands of pounds? Let's find out.

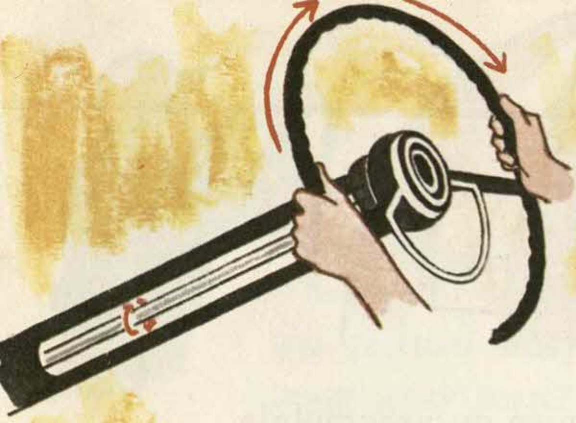
The handle and drum turn together. The handle is like a wheel; the drum turns on an axle with the wheel. A wheel and axle is like a lever. Look at the diagram. Where is the fulcrum? E? R?

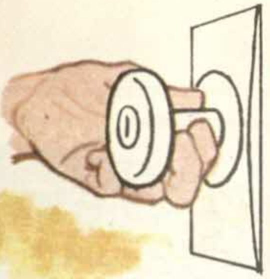


Tie a pencil to the end of a piece of string. Cut the string 18 inches long, and use it to draw a circle on a large piece of cardboard. Cut out the circle and measure around it with another piece of string. What is the distance the man's hands moved?

Prepare a piece of string 6 inches long and do the same with it. How far was the auto moved when the handle was turned around once? How does a wheel and axle make work easier to do?





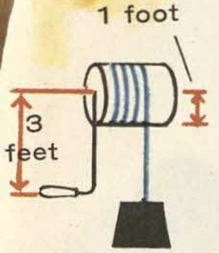


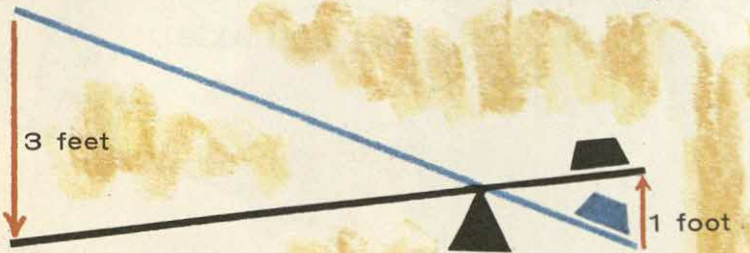
The doorknob is a wheel and axle. Try to open the door by turning the axle. Why is it harder to do?

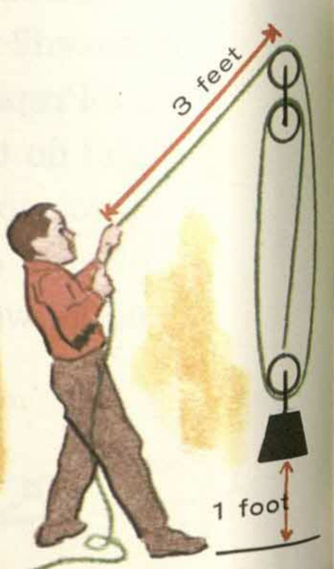
The steering wheel of an automobile is another example of a wheel and axle. Use a piece of string and find out how much farther the driver's hands move on the wheel than the axle turns. The wheel and axle acts like a lever. Look at the picture.

What other examples can you think of?

The pulley, the lever, the wheel and axle—all these simple machines make work easier. We use a small force through a greater distance.







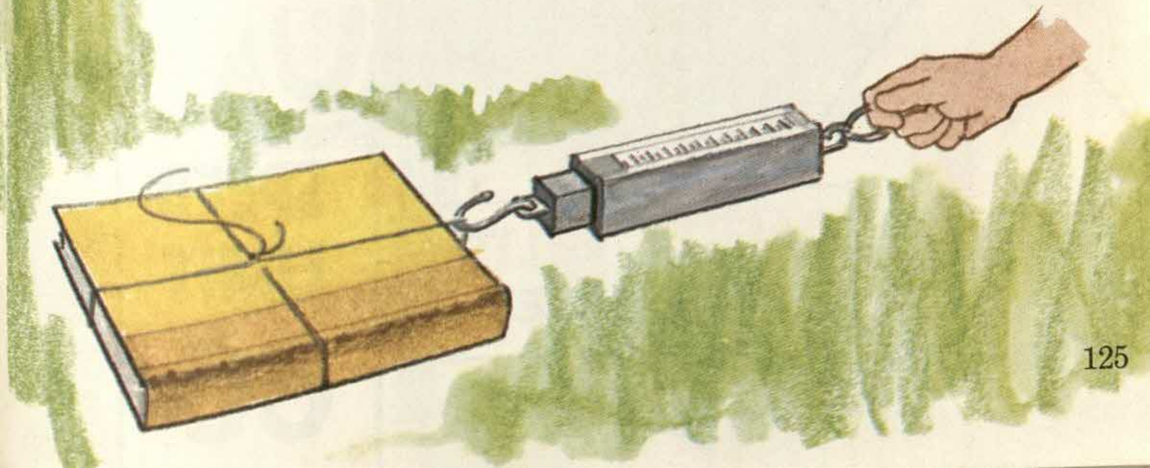
When we lift an object, we have to work to overcome gravity. What else do we have to overcome? Let's see.

Weigh a book. Put the book on a table. How great is the book's push on the table? What is the table's push on the book? How do you know?

Pull the book along the table with the spring scale. What is the pull needed to move the book? Is the pull the same as the weight of the book? Greater? Less? Why?

The book on the table is at rest; it is not moving. Objects at rest remain at rest. When you put the book on the table, it stays there. If it moves, you look to see what or who moved it. To move the book on the table you must use a force.

Pull the book along the table top with the spring scale. Do this several times. When was your pull greatest? When was it least?



What does a body at rest always do? Why was the pull greatest at the beginning? Why was the pull less after the block was in motion? Let's try to find out.

Put a ball in a shoe box from which one end has been cut off. Push the box and stop it suddenly. What happens to the ball when the box stops?

A body in motion remains in motion in a straight line. The box was stopped by you; the ball continued to move.

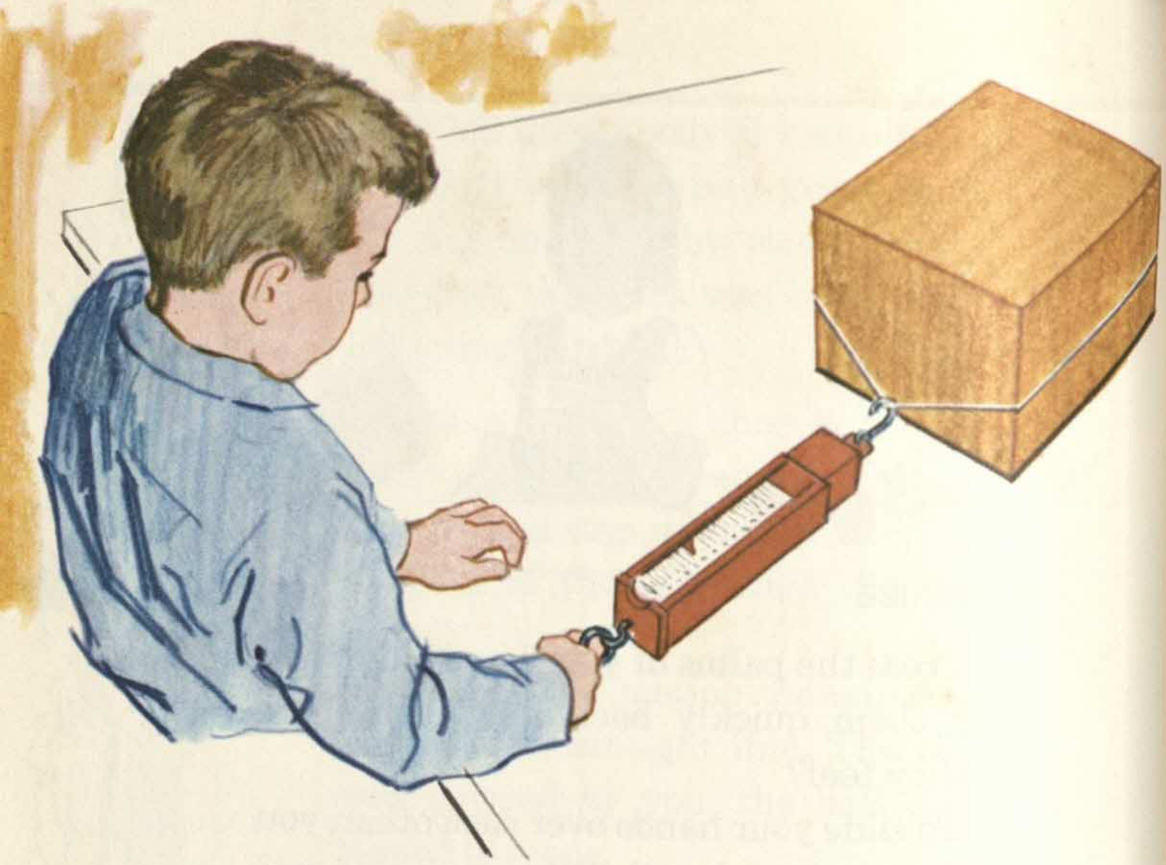
The word inertia (in-ER-sha) is used to name the way a body at rest remains at rest and the way a body in motion remains in motion in a straight line. Sometimes inertia helps us to do work; sometimes it makes work harder. Think of some examples of each.

DESCRIBE

Press the palms of your hands together. Slip them quickly back and forth. How do they feel?

To slide your hands over each other, you had to push and pull. Whenever one surface moves over another, there is a force acting against the movement. This force is called friction. Friction may cause the surface to become warmer.

How could you decrease the friction between two surfaces?



ACTIVITY

Place a piece of sandpaper on the bottom of the outside of a cardboard box.

Attach a spring scale to the box. Now pull the box along the top of a flat surface. Do this several times and record your results. Now add two or more books to the top of the box and repeat the activity. What do you observe?

Try the entire activity without the sandpaper.

What happens this time?

What do your results seem to show?

How can we reduce friction?

COMPARE

Fasten your spring scale to a cardboard box.

Add books to increase the weight.

Pull the box across your desk.

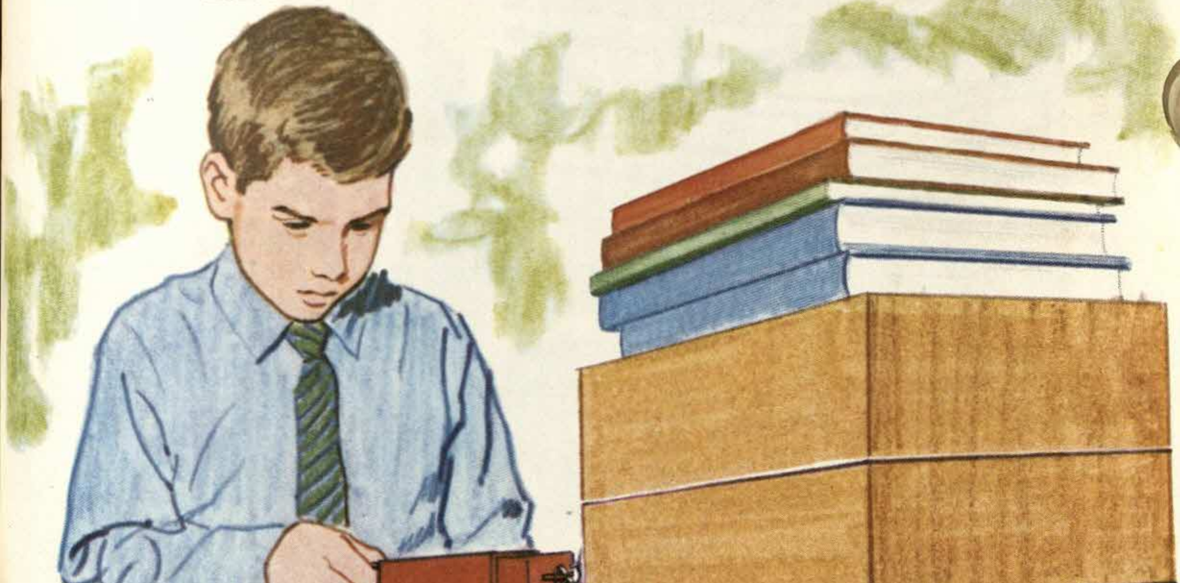
What is the reading on the spring scale?

Now place several round pencils under the box.

Pull the box again. What is the reading for the spring scale this time?

Add more books to the top of the box and pull the box again.

Can you describe one way of decreasing friction?



ACTIVITY

Fasten several books together with a piece of string.

Try to turn the books with a spring scale.

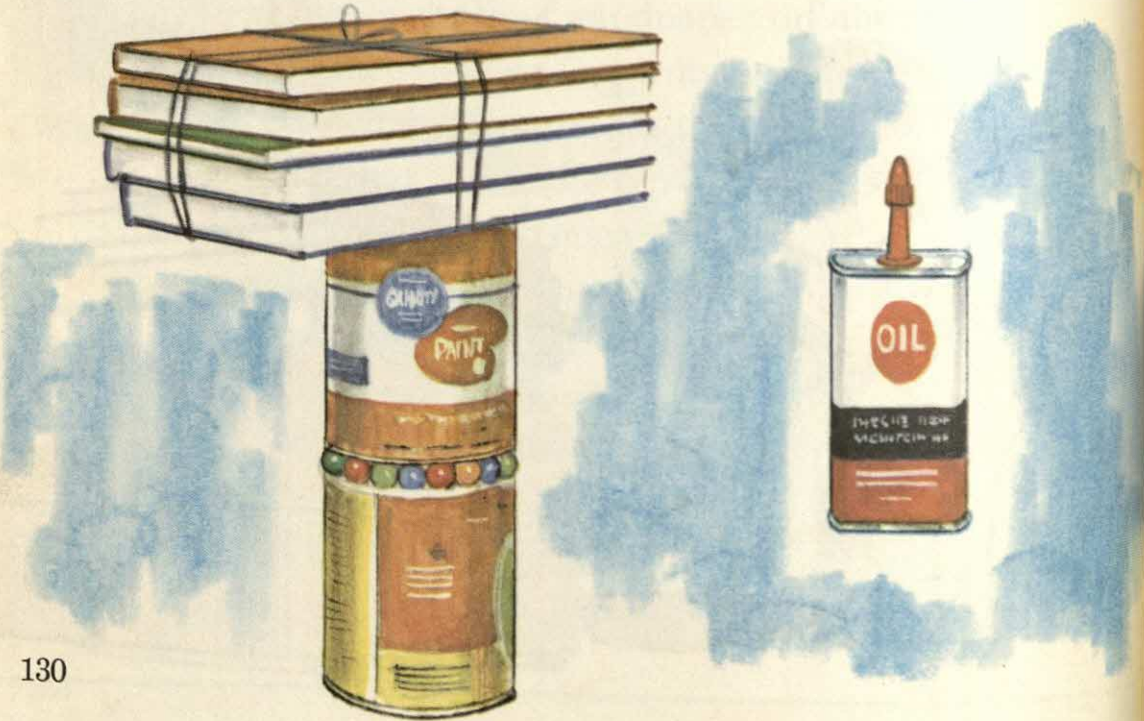
How much force was necessary to turn the books?

Now make a *bearing* with two paint cans and several marbles.

Place the same package of books on top of the paint cans.

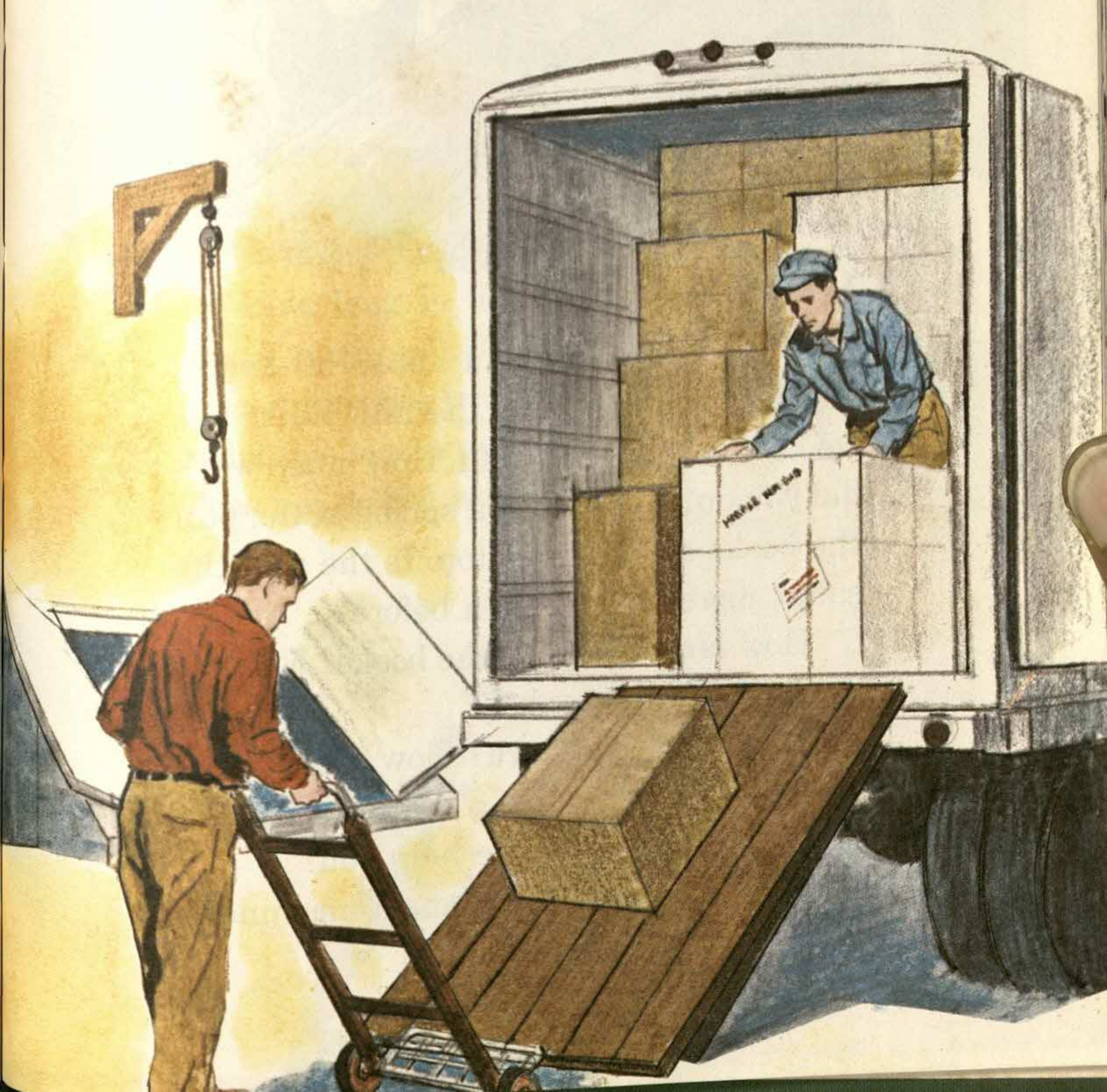
What happens now when you turn the books?

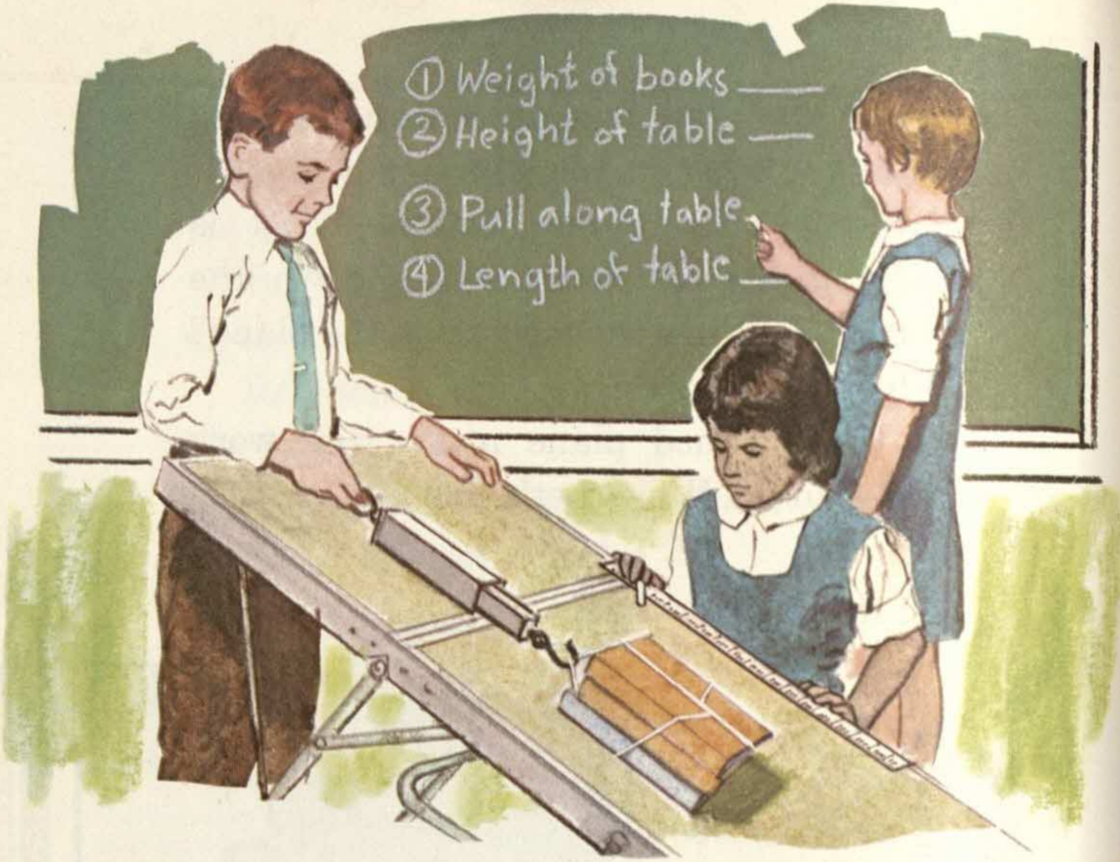
Does using oil help reduce friction? How do you know?



Gravity and friction sometimes help make work easier. Sometimes they make it harder. Look at the picture. What is keeping the box from sliding down the plank? Why are the men using the plank? Why don't they lift the box?

The inclined plane makes the work easier to do. Why? Let's find out.





ACTIVITY

Make a hill from a table or board. Measure the height of the hill. Raise the books to the top of the hill. How much work did you do? Now using a spring scale, pull the books along to the top. Is the pull the same, more, or less than before?

How far did you lift the books? How far did you pull the books?

What did you learn? How much work did you do?

How did this incline help you?

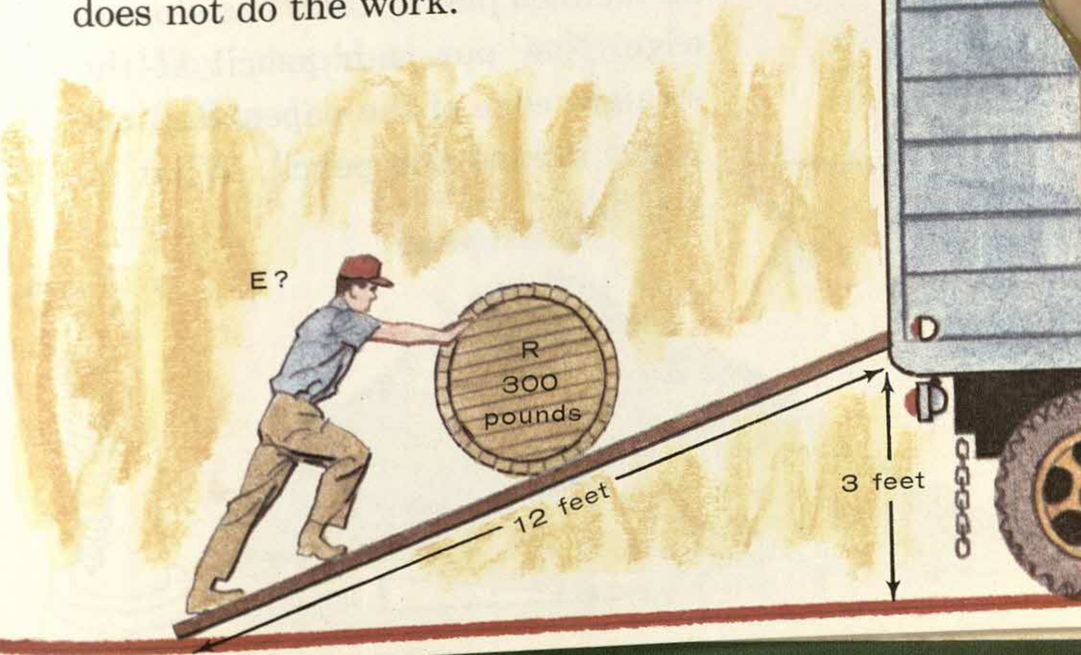
Why is an inclined plane a machine?

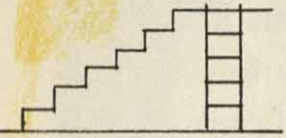
You needed less force to pull the books up the table. You did the same amount of work as when you lifted the books, but it was easier. How could you have made the pull up the table less? Try it again and put the books on wheels. Is the pull the same, greater than, or less than before? Why?

OBSERVE

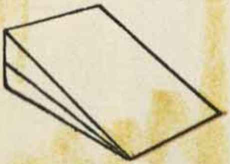
Look at the diagram below. Could the man lift the barrel into the truck? How much work would he do? The work done is equal to the weight of the barrel times the distance he could lift it.

How long is the inclined plane? How much push will the man need to roll the barrel into the truck? Remember a simple machine makes work easier to do but it does not do the work.





Stairs are inclined planes. Would it be easier to climb the stairs or to climb a ladder to the next floor? Why?

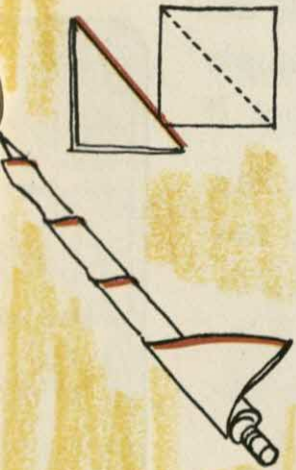


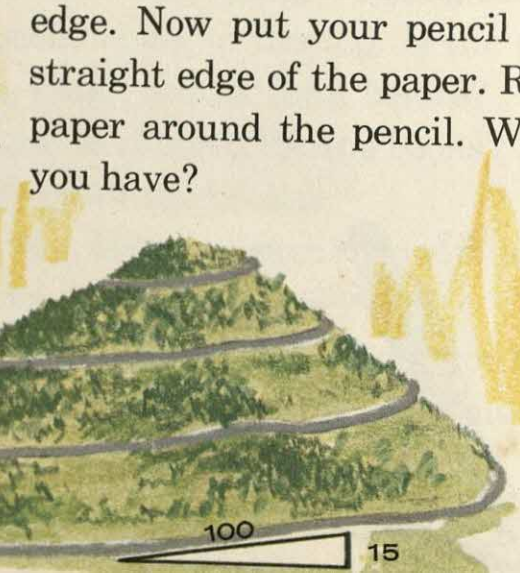
Put two inclined planes together. What do you have?

Roads up the mountain side are really inclined planes. How do they help us climb the mountain? Look at a small piece of the road. How much higher are you at the end of a 100-foot drive on the road? Road planners must be careful to grade the road for safety.

ACTIVITY

Try this. Fold your paper the way the diagram shows. You have an inclined plane. Color the sloping edge. Now put your pencil at the straight edge of the paper. Roll the paper around the pencil. What do you have?





DESCRIBE

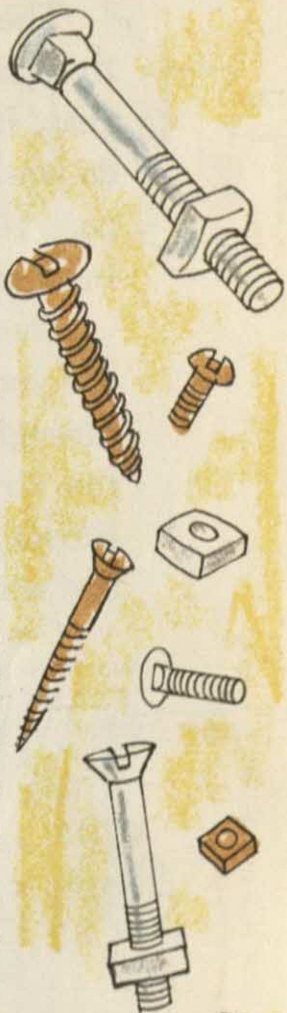
Look at the picture of the screw. How is it like a mountain road?

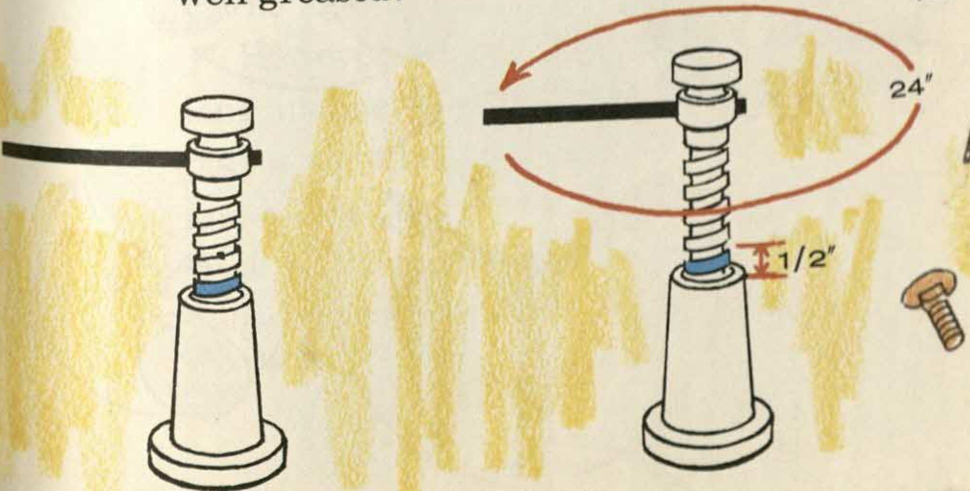
There are many kinds of screws. Look at the pictures. What is different? What is the same?

Look carefully at the diagram of the jackscrew. How far does the screw move each time the handle is moved back and forth? How far does the handle move each time?

A small force pushing or pulling through a great distance produces the same amount of work as a great force pushing or pulling through a small distance. The work you put into the machine is about equal to the work put out by the machine.

Why should the jackscrew be well greased?

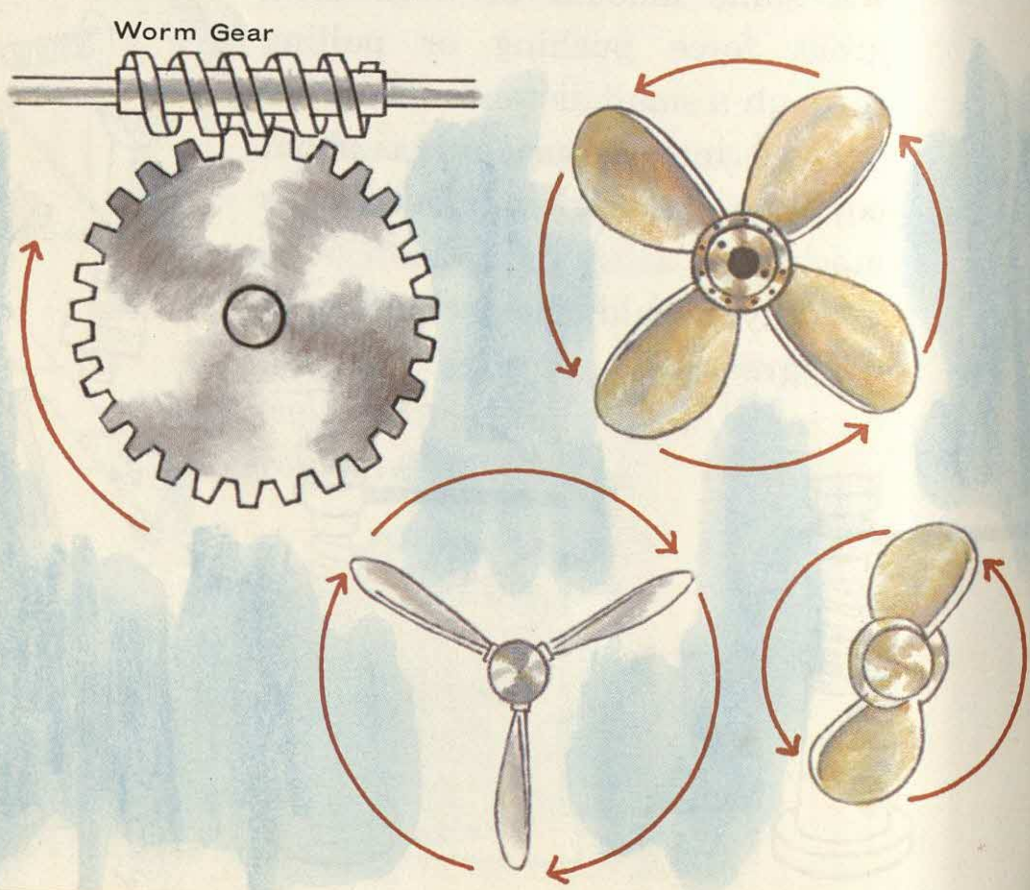


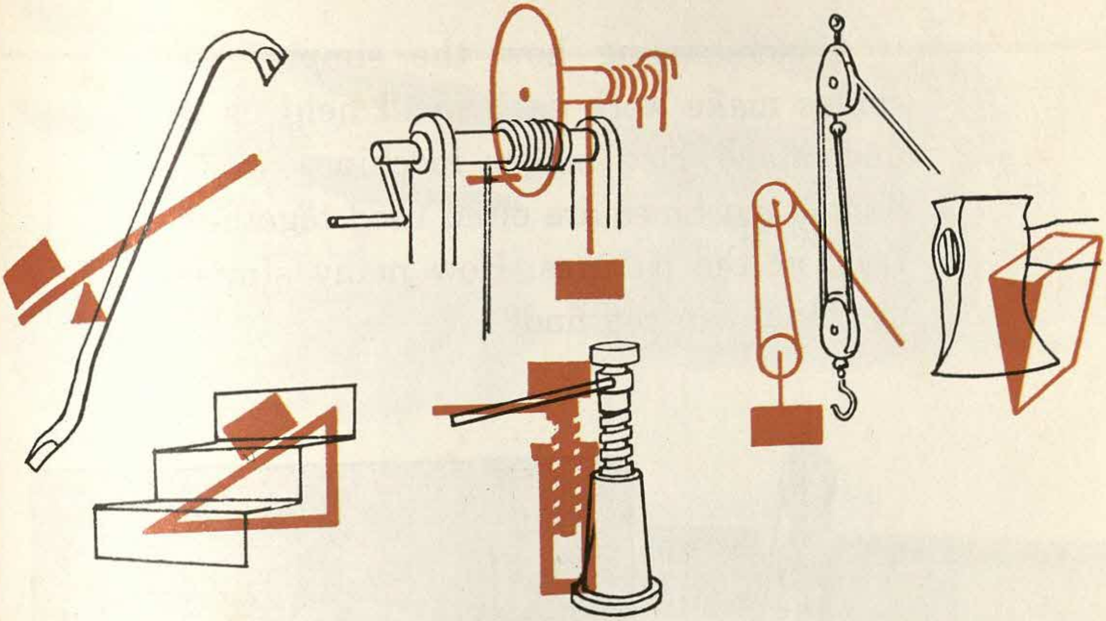


OBSERVE

The worm gear is another example of the screw. Look at the picture of the worm gear. How does the worm gear help us to do work? How many times will the worm gear turn when the big gear turns once? In what direction does the worm gear turn?

There are air screws and water screws. Air and water tend to stop things moving through them. There is friction between the air or water and the moving object. Propellers screw the objects through air and water.

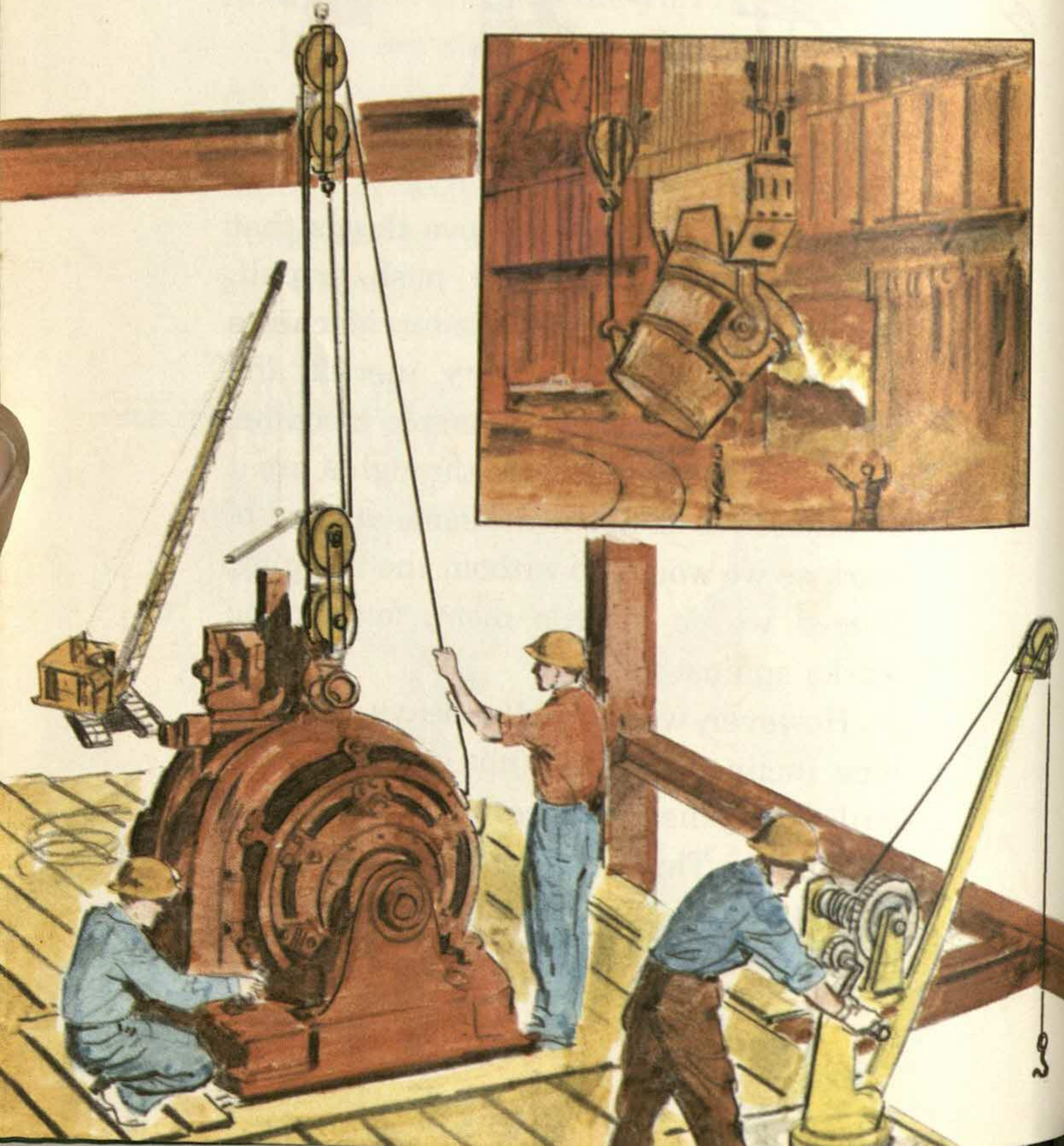


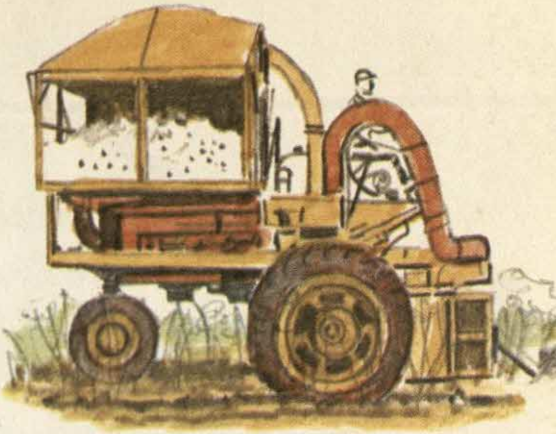


Machines help us to move things that are too heavy for us to lift, push, or pull. Machines help us to move faster. Machines help us to overcome gravity, inertia, and friction. When we use a simple machine, we often use a small force through a great distance. We do about the same amount of work as we would do without the machine. Indeed we do a little more, for friction works against us.

However, we can pull a heavy box up a long incline. We could not lift it. We can pull a very heavy object up with a block and tackle. Think of each simple machine. Look at the picture. Explain how each one helps us to do work.

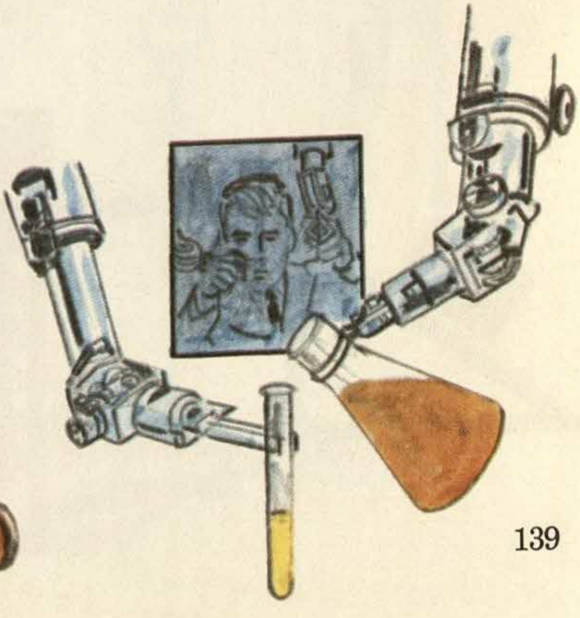
Understanding how the simple machines make work easier will help us to understand how bigger machines work. Simple machines are often used together. Look at the pictures. How many simple machines can you find?

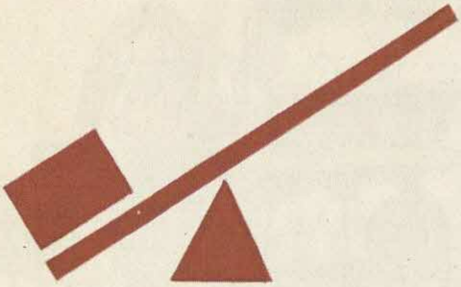


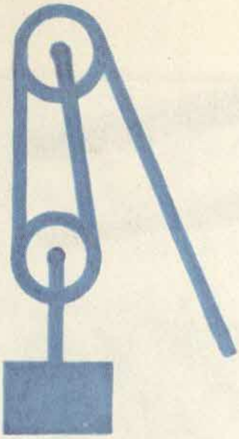


Long ago all machines were operated by muscle power. Today we have learned to use other forces instead. Name some ways man uses other forces to drive his machinery.

Today new forces are being studied. Soon new machines will be needed, new plans will be made, new ideas will be looked for. You may be planning these new machines. You may be using old ideas in very new ways.





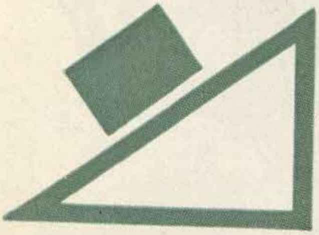


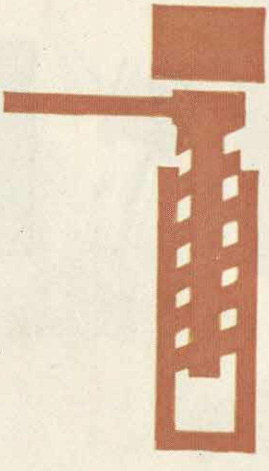
THINK

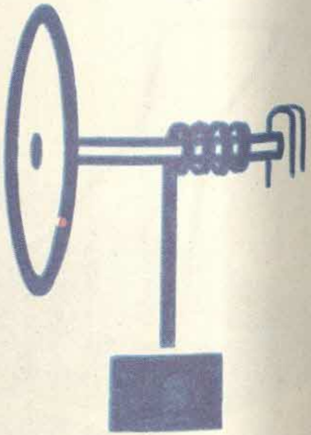
If you had to move a heavy log, which of the machines you have learned about would you use? Why?

Friction may at times be either necessary or unnecessary. Give some examples of both.

A wedge is a double inclined plane. Why would a wedge be easier to use in splitting a log than a single inclined plane?



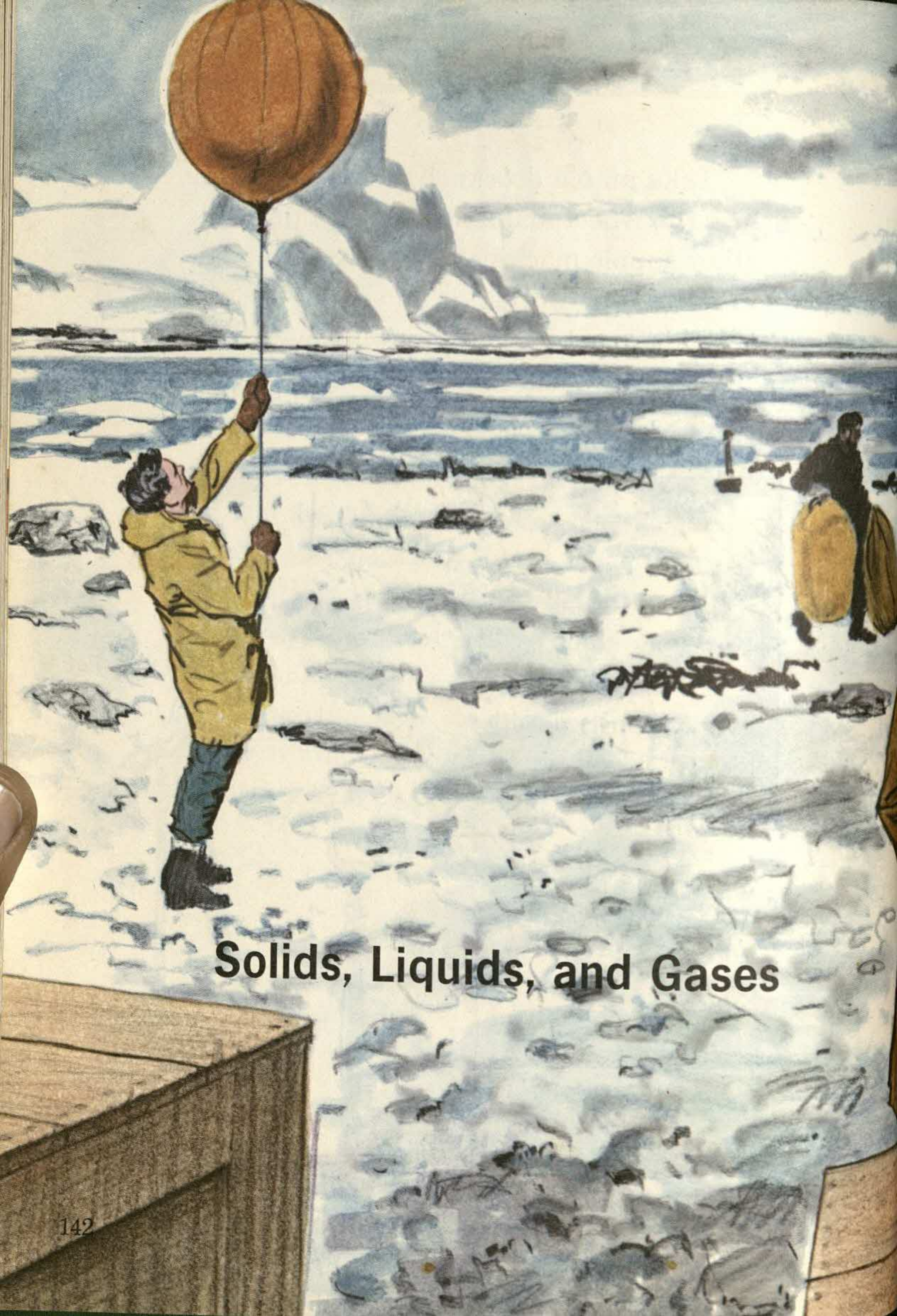




PROJECTS

Take an old doorknob apart and try to find the wheel and axle. Can you find any other simple machine? Try to explain how the doorknob works.

Look at all the machines in your kitchen. Classify them according to type.



Solids, Liquids, and Gases

4V

All substances can be found in one of three forms: solid, liquid, or gas. Substances change from one form to another. Do you know what the three forms of water are?

Some substances look so much alike that it is difficult to tell them apart. They are as similar as identical twins, triplets, or even quintuplets. Sugar and salt are almost like twins. Could you tell them apart? How?

How can you tell some substances apart?

DESCRIBE

Describe the salt and sugar. Can you tell them apart by sight? How do they feel? Are they hard, soft, round, smooth? Sniff them. Do they have any odor? Could you tell them apart by taste? What might happen if one of the substances were poison? Is tasting a good sense to use if you do not know what a substance is? Why?

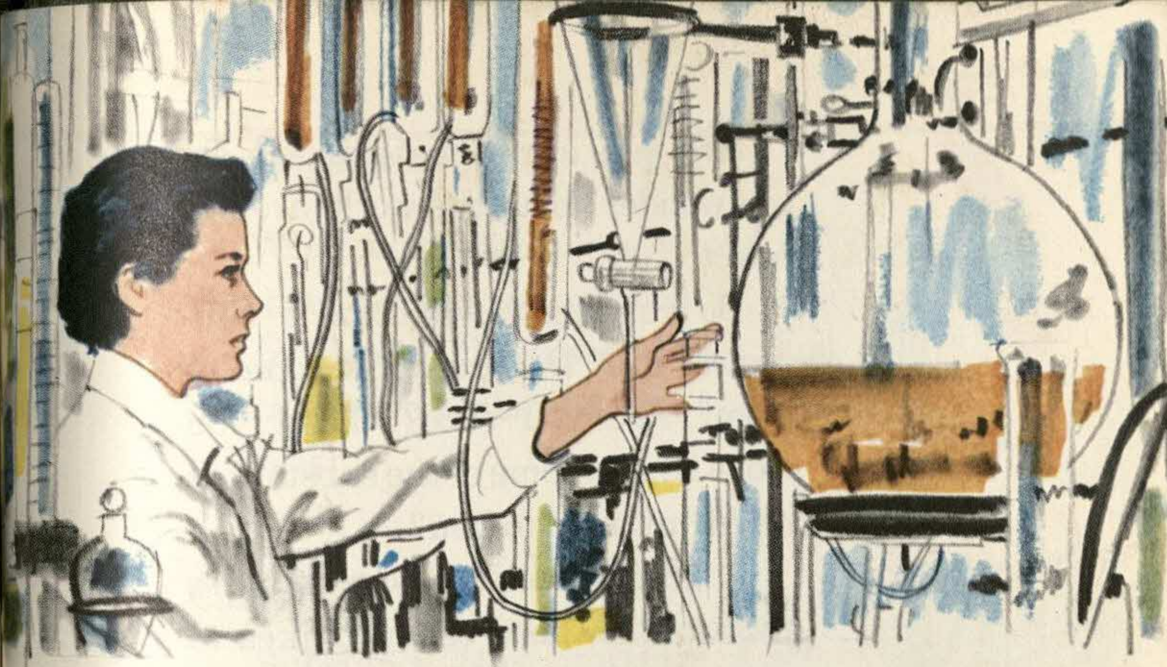
RECORD

Make a chart showing how you tested these substances.

Testing Solids

A chemist is a scientist who tries to learn as much as he can about substances. He observes how substances change. Then he is able to identify them, understand them, and use them. Many substances are so much alike that he cannot tell them apart by simply using his senses. By experimenting, he discovers that substances often change differently when things are done to them. The chemist observes the way they change. This helps him identify the substances.

In this unit you will do some simple



tests. They will help you tell what a substance is. The tests you will make are the same ones that the chemist uses. Let's see what they are.

Here are several white substances to work with one at a time. Use your senses to study them carefully.

Do not taste the substances!

RECORD

Organize your observations on a chart. When you finish each test, write down what you have observed.

Do you know what any of the substances are?

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Are you a curious person? Do you wonder about the world around you?

Do you know what the 5 substances are? Do you know some of them? Are you sure? Could you prove it? Are some of the substances still a mystery to you?

A good detective likes to solve mysteries. A good chemist likes to solve the mysteries of substances. To solve mysteries, detectives and chemists need information. They look for clues to help them. In a moment you will have two mysteries to solve. First you will need some information. Soon you will discover some clues.

Information

You observed 5 white substances. Substance #1 was powdered sugar; #2 was starch; #3 was baking soda. Did you know any of these?

Two Mysteries

What were substances #4 and #5? Now you are the detective or chemist. It is your job to identify these substances. You may guess, but you must be able to prove your guesses.

Clues

Substance #4 is a mixture of two of the other substances. You have to find out which two. Is it sugar and starch? Or is it starch and baking soda? Maybe it is baking soda and sugar. How can you find out? Substance #5 is also a mixture of two substances. Which ones?

How can you find more clues to the mystery substances? One way is to test the substances you already know.

Test 1

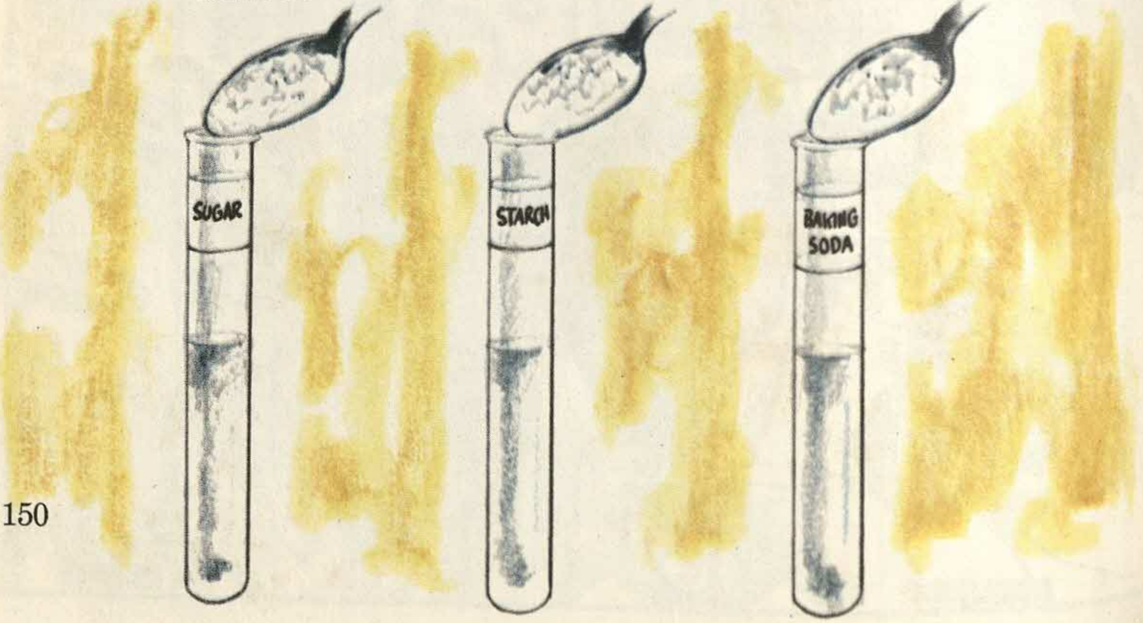
The first test is to find out what water does to the three white substances: sugar, starch, and baking soda.

Half fill three test tubes with water. Label them.

Put one level teaspoon of each substance in each of the test tubes. Shake each tube so that the substances mix with the water. Let the test tubes stand for 5 minutes. What happens to the sugar? the starch? the baking soda?

RECORD

Label your chart. Write "water" under Test 1.



Now test the mystery substances. Label two new test tubes. Half fill them with water. Put one level teaspoonful of each substance in each test tube. Shake well and let them stand for 5 minutes. What happens?

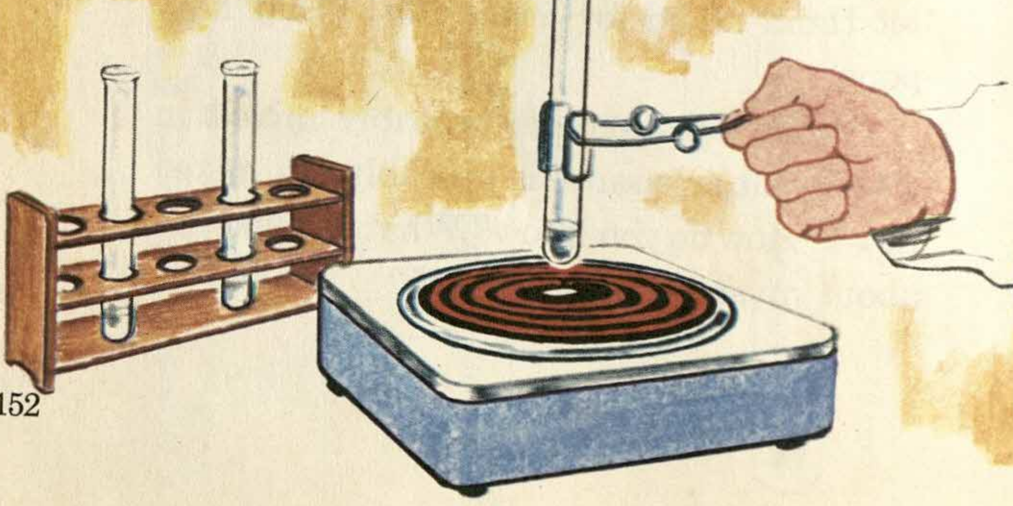
What substance is probably mixed in #4? What substance is probably not mixed in #4? How do you know? What can you say about mystery substance #5?

Test 2

Substances often change when they are heated. The second test is to see what heat does to sugar, starch, and baking soda. With this test, you will discover more clues to help you identify the mystery substances.

Put one level teaspoonful each of sugar, starch, and baking soda into 3 test tubes. Heat each test tube on a hot plate. What happens? Write what you have observed on your chart.

Now test the mystery mixtures, #4 and #5, in the same way. What do you observe? Did the sugar, starch, and baking soda test give you some clues? Are any of these substances in the mixtures? How can you tell?



Test 3

You will need a small bottle of iodine solution. Be careful not to get it on your hands!

Put one teaspoonful each of sugar, starch, and baking soda into 3 test tubes. Add a few drops of the iodine solution to the sugar.

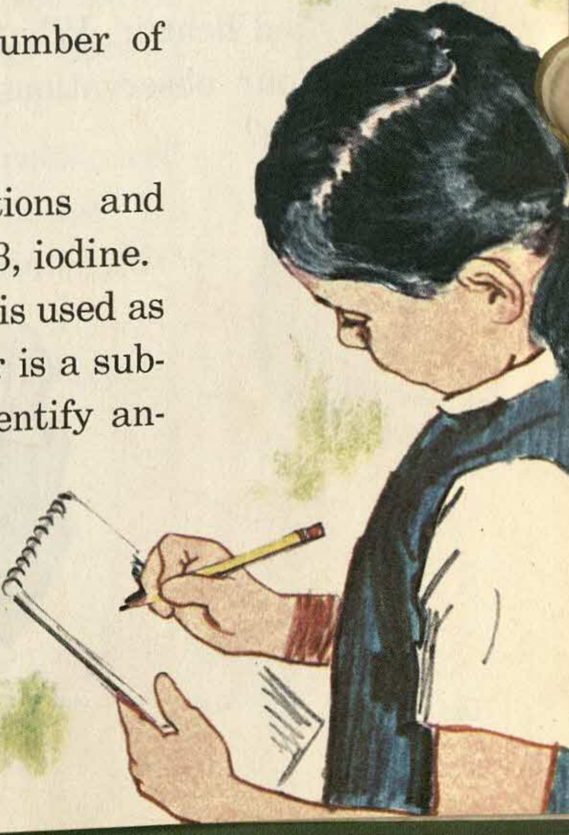
Add the same number of drops to the baking soda.

Now add the same number of drops to the starch.

What do you observe?

Record your observations and label your chart for Test 3, iodine.

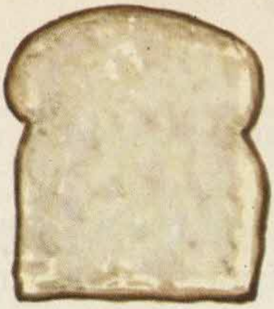
The iodine in this test is used as an indicator. An indicator is a substance which helps us identify another substance.



Chemists use indicators to learn more about substances. They add the indicator to a substance to see if a change occurs.

How can you use indicators to give you clues to your mystery mixtures?

Benedict's solution is often used as an indicator. Add this solution to simple sugar and heat it. What happens? Record all of your observations. What colors did you see?



The chemist uses iodine to test for starch. He knows that starch is present when he sees a blue-black color after he uses the iodine.

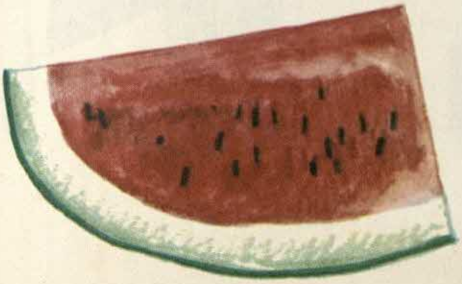
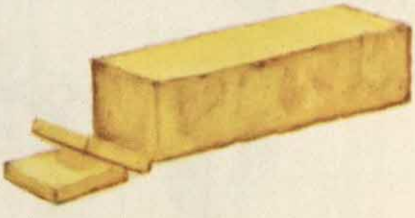
OBSERVE

Now test a few more substances with the iodine solution to see if they contain starch.

First take a small piece of white bread. Put a few drops of the iodine solution on it. What color does it turn?

Take a small piece of potato and do the same. What do you see? Do bread and potatoes contain starch? How can you tell?

Now test the mystery mixtures. What do you discover?

Test 4

For this test you will use vinegar as an indicator. Half fill three test tubes with water. Add one level teaspoonful of sugar, starch, and baking soda to each tube. Label them. Shake them well.

Now add one teaspoon of vinegar to each test tube. Observe what happens. Label your chart for Test 3, vinegar. Record what you see.

Baking soda is sometimes called bicarbonate of soda. It contains a substance called carbonate. Vinegar reacts with any substance containing a carbonate. You can learn if a substance contains a carbonate by using vinegar as an indicator.

ACTIVITY

Test your indicator by putting some ground chalk into a test tube half filled with water. What happens? What have you learned about chalk?

Now use your vinegar indicator on mixtures #4 and #5. Do either of these mixtures contain a carbonate?

Look at your chart. What happens to sugar when you put it in water? What happens when you heat it? What happens when you test it with iodine or vinegar?

What happened to mystery mixture #4? Would you say that one of the substances in the mixture was sugar?

Look at your chart again. What did you observe about starch in each test? Did mixtures #4 and #5 react in the same way? Is starch one of the substances in mixture #4? in mixture #5?

What happened to the baking soda in each test? Did mixtures #4 and #5 behave in the same way?

What were the two substances in mixture #4? How can you tell?

What were the two substances in mixture #5? Prove it.

So far you have been testing solid substances. You may also test liquids and gases.

How could you test liquids? Do you know any indicators you might use? One indicator chemists use is litmus paper. It comes in two colors: red and blue.

ACTIVITY

Your teacher will show you how to use it. Use the blue litmus paper first to test different kinds of liquids such as lemonade, vinegar, orange juice, and liquid bleach. Test as many liquids as possible. Make a list of the liquids which changed the color of the litmus paper. Make another list of those which did not change the color.

Now test the same liquids with the red litmus paper. Make new lists showing which liquids change the color of the red litmus paper and which do not.

Do you notice anything unusual about your lists?

Red cabbage juice is another indicator chemists use.

ACTIVITY

Prepare some red cabbage juice by squeezing and straining red cabbage leaves. Take various liquids, such as lemon juice, orange juice, grapefruit juice, ammonia water, salt solution, sugar solution, and other liquid solutions which you might have. Add them to the cabbage juice. See how many different shades of color you get. Keep a record of the color changes.

How do you results compare with your tests using litmus paper?

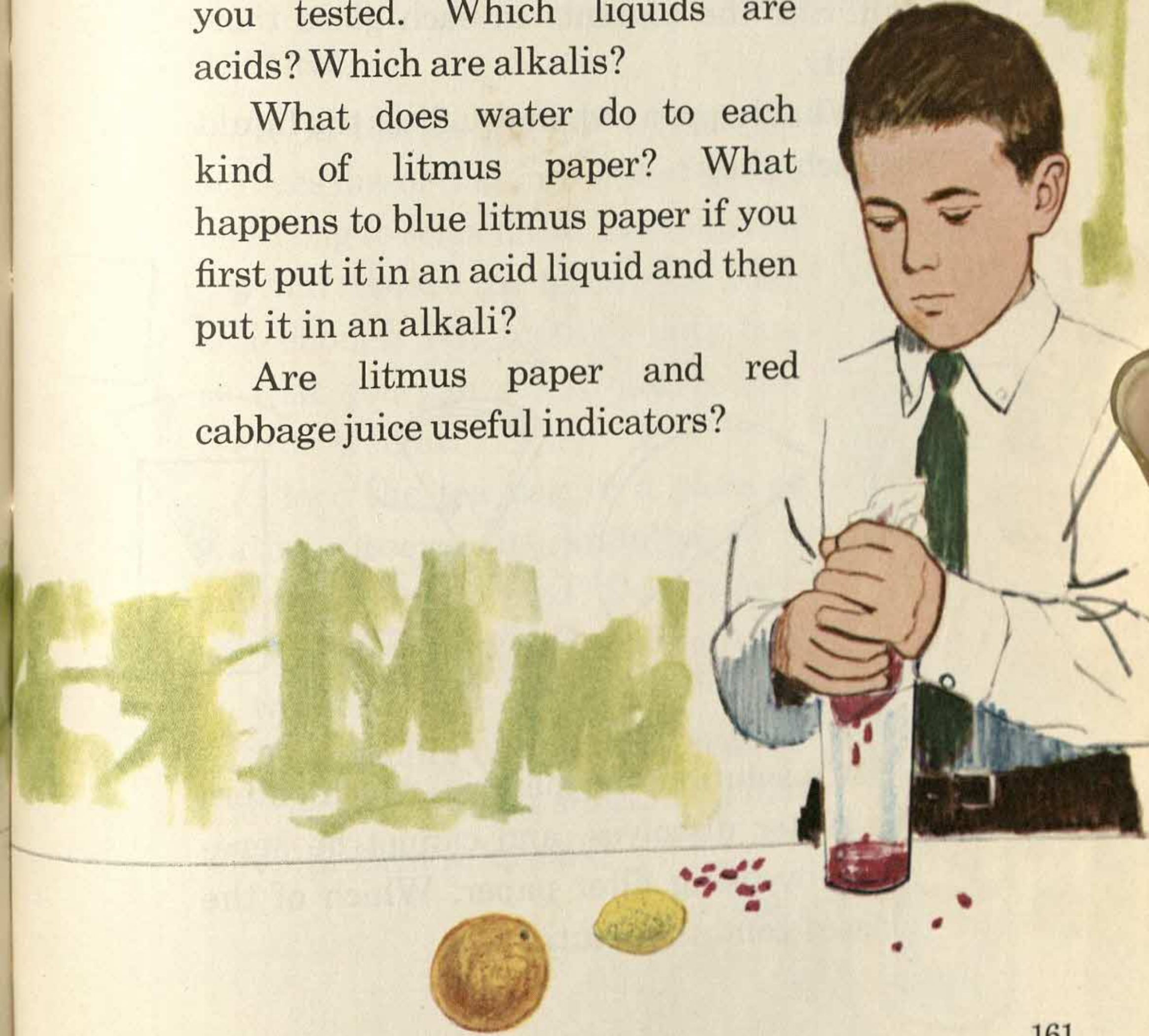
Liquids that turn blue litmus paper red are called acids. Liquids which are the opposite of acids are called alkalis (AL-kuh-lyes). Alkalis turn red litmus paper blue.

Checking Your Records

Look at the list of liquids that you tested. Which liquids are acids? Which are alkalis?

What does water do to each kind of litmus paper? What happens to blue litmus paper if you first put it in an acid liquid and then put it in an alkali?

Are litmus paper and red cabbage juice useful indicators?



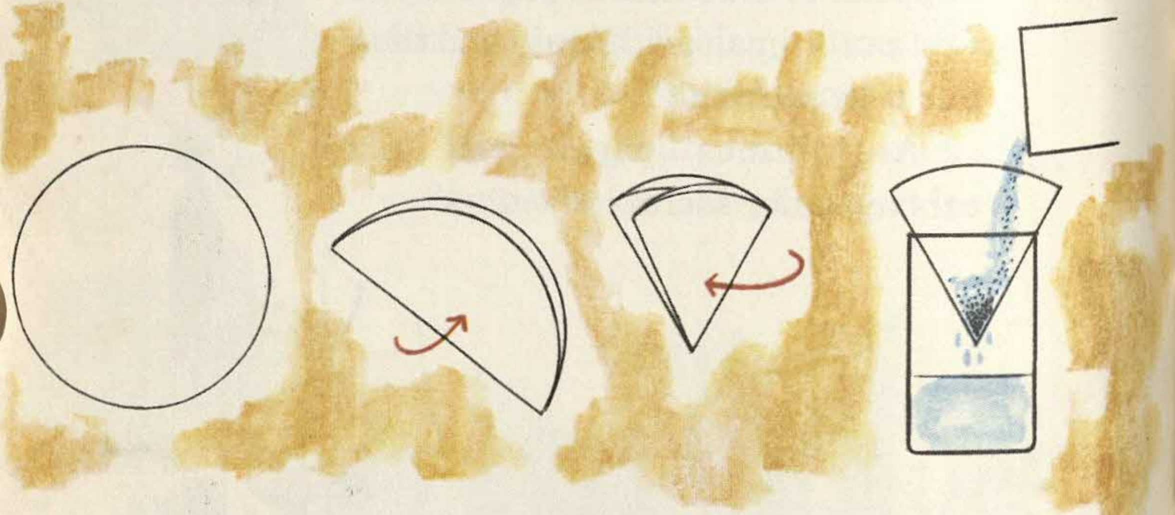
ACTIVITY

Do you know what a solution is?

Take seven glasses and place some sand in one, gravel in another, sugar in another, salt in another, iron filings in another, copper sulfate in another, and mud in the seventh glass.

Now add water until each glass is half full. Stir the contents in each glass thoroughly.

What happens when you filter the liquid in each glass?



In a solution, the material which enters the water dissolves, and cannot be separated by using filter paper. Which of the glasses contains solutions?

ACTIVITY

Carefully put a tiny piece of copper sulfate in a glass half filled with water. Watch it closely. What do you see as the chemical dissolves into the water? Do you think a solution has been formed? How would you test to tell?

OBSERVE

It is interesting to watch substances dissolving into water. Bring a tea bag to school. Cut a hole in the top and remove the tea leaves. Now add enough salt to the empty bag so that you can see it clearly and feel its weight.

Place the tea bag in a glass of water. Observe it carefully. Is a solution being formed? Does it look the same as the chemical dissolving in water?

Try placing other substances in the tea bag. Which substances dissolve to form solutions?

How can you separate water from the material dissolved in the water? Can you suggest a few ways to separate them?

ACTIVITY

Make a salt solution, by adding one tablespoon of salt to half a glass of water. Mix thoroughly.

Filter the solution through your filter paper. Let the filter paper dry. What do you see?

Does the solution in the glass look clear? Does it contain salt? How can you find out?

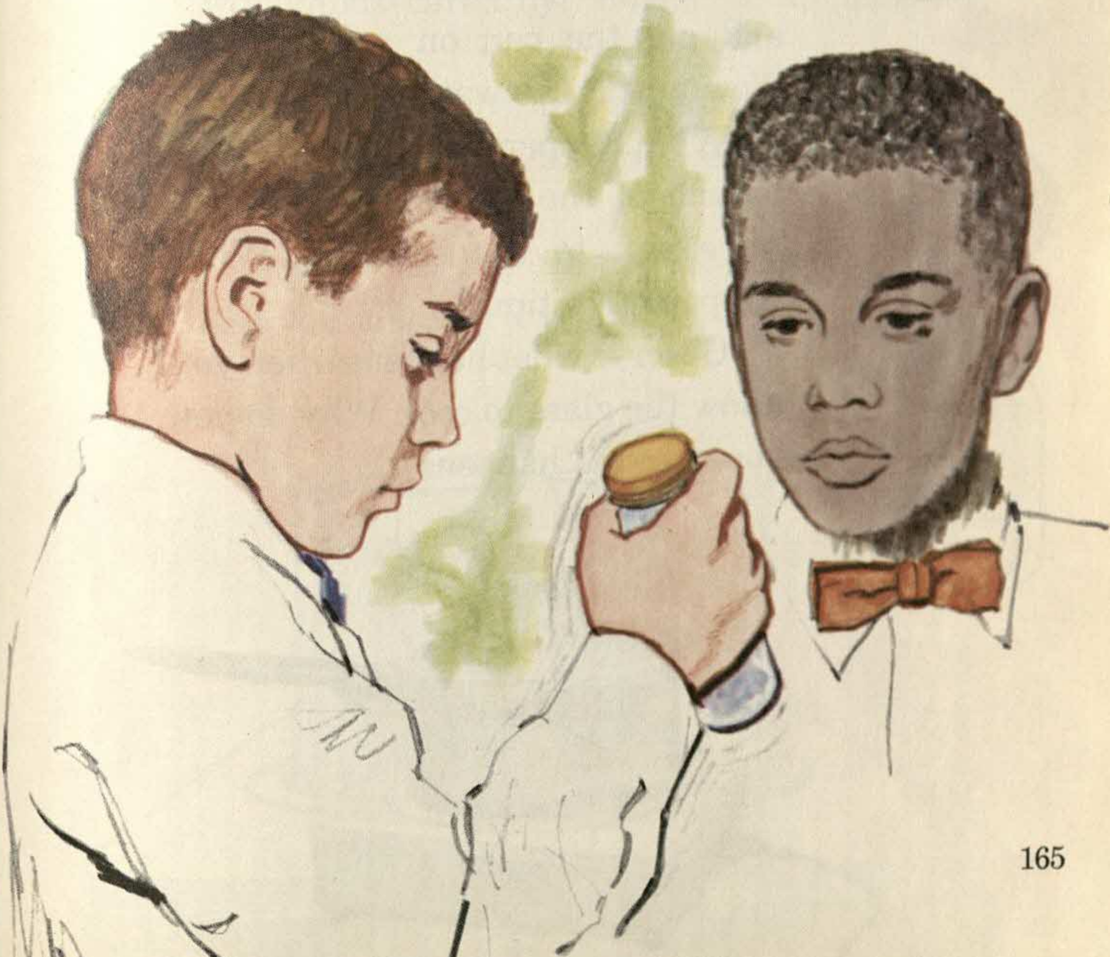
ACTIVITY

Fill a narrow jar with a mixture of oil and water. Screw the cap on tightly. What do you see? Now shake the jar quickly a number of times. What do you see?

Place the jar on your desk and observe it closely. What do you notice happening?

Can you make a solution of oil and water?

How would you separate the oil from the water?



What effect does heat have on our ability to prepare solutions? Let's find out.

ACTIVITY

Start with a glass half filled with cold water. Add salt to the water until you cannot get any more salt to dissolve. Stir continuously. Make sure that no more salt will go into solution.

Place the glass in a pan of water, and put the pan on a hot plate. Slowly heat the water.

What happens to the salt on the bottom of the glass? Add a little more salt to the solution. What happens this time?

Observe what happens when you allow the glass to cool. Why do you suppose this happens?

The temperature at which liquids boil is called the boiling point. How can you find out the boiling point of two liquids?

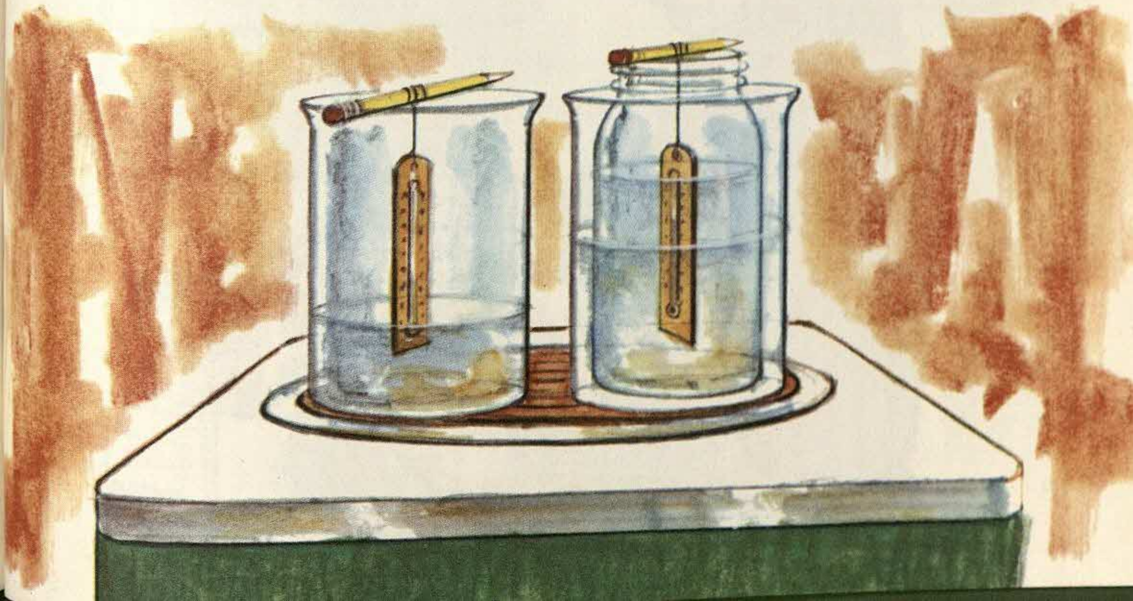
ACTIVITY

Take two beakers and fill them $\frac{1}{4}$ full of water. Place both on a hot plate. Hang a thermometer in one beaker.

Fill a small glass $\frac{3}{4}$ full of alcohol. Put the small glass in one beaker. Hang a thermometer in the small glass. Observe the two liquids carefully. Which liquid boils first?

At what temperature does the alcohol boil? At what temperature does the water boil?

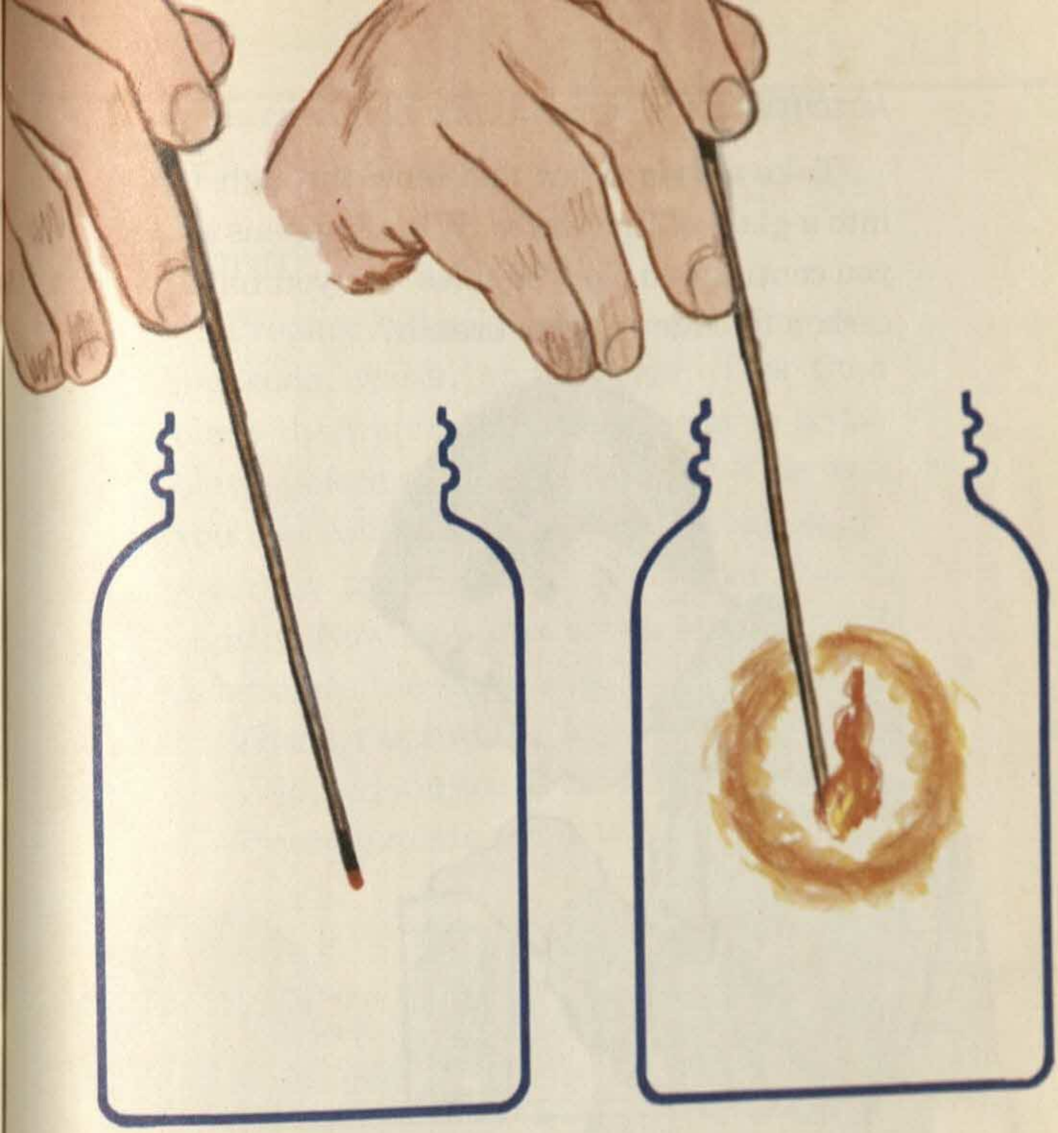
How would you use this information to help you identify a liquid?



Testing Gases

Put a few spoonfuls of baking soda in a plastic bag. Add a half test tube of vinegar to the baking soda. Close the opening of the bag. Watch. What forms inside the bag?

Prepare some more of this gas in a test tube. What happens when a glowing splint is placed in this gas? What happens when this gas is poured over a burning candle? The gas that forms is called carbon dioxide.

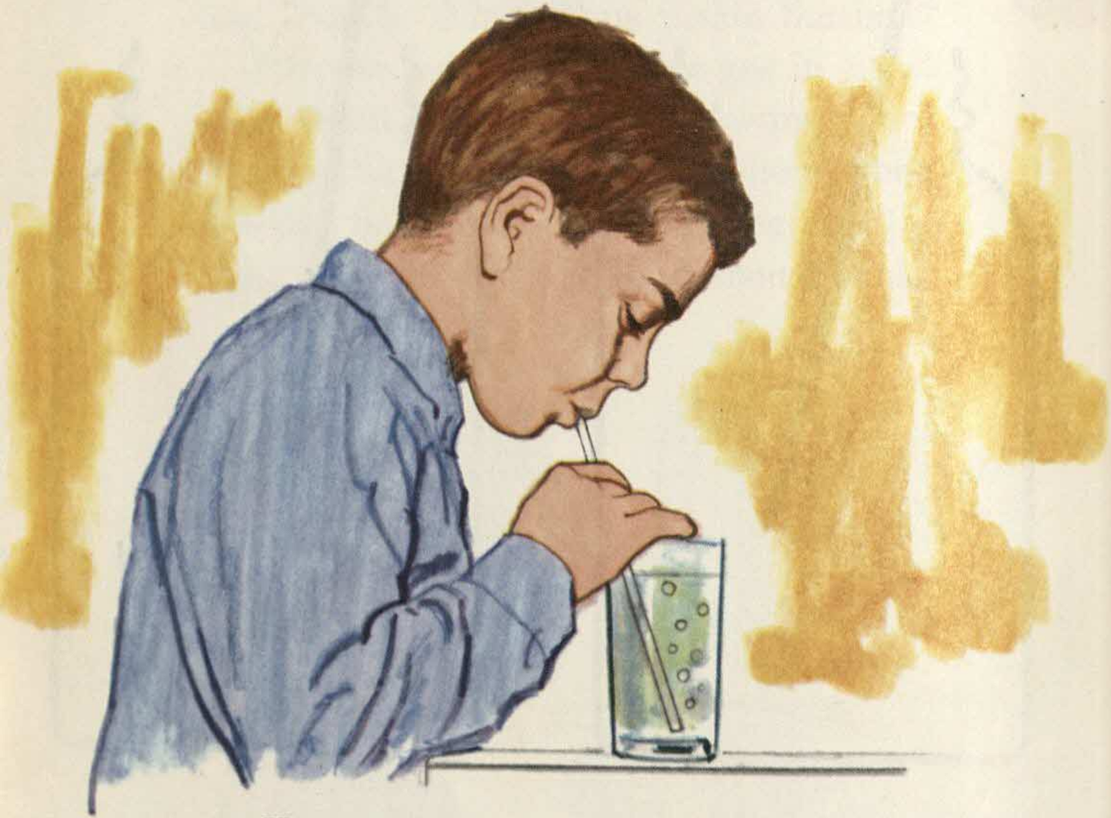


You have seen what happens to a glowing splint when it is placed in carbon dioxide. What happens to a glowing splint when it is placed in oxygen?

How can you tell the difference between oxygen and carbon dioxide?

ACTIVITY

Take a soda straw and blow through it into a glass of limewater. What happens as you continue to blow bubbles? Do you have carbon dioxide in your breath?



You discovered that limewater turns milky white in the presence of carbon dioxide.

When other gases are bubbled through limewater, this did not happen. Is limewater an indicator?

Is carbon dioxide heavier or lighter than air?

ACTIVITY

Prepare carbon dioxide again using baking soda, water, and vinegar. This time place the water and baking soda in a pop bottle before adding the vinegar. This way you can collect the gas inside a balloon.

After the gas fills the balloon, tie it tightly. Now blow up another balloon until it becomes the same size.

Throw the two balloons up into the air. What do you see as they fall back down? Try to explain what this means.

ACTIVITY

Pick up a small quantity of dry ice with tongs. Put it in water. Handle the ice carefully. Put a small amount into a plastic bag so it can melt inside. Close the opening of the bag and observe what happens as the dry ice changes.

What can you find out about the gas?

What tests would you use to learn about this gas?

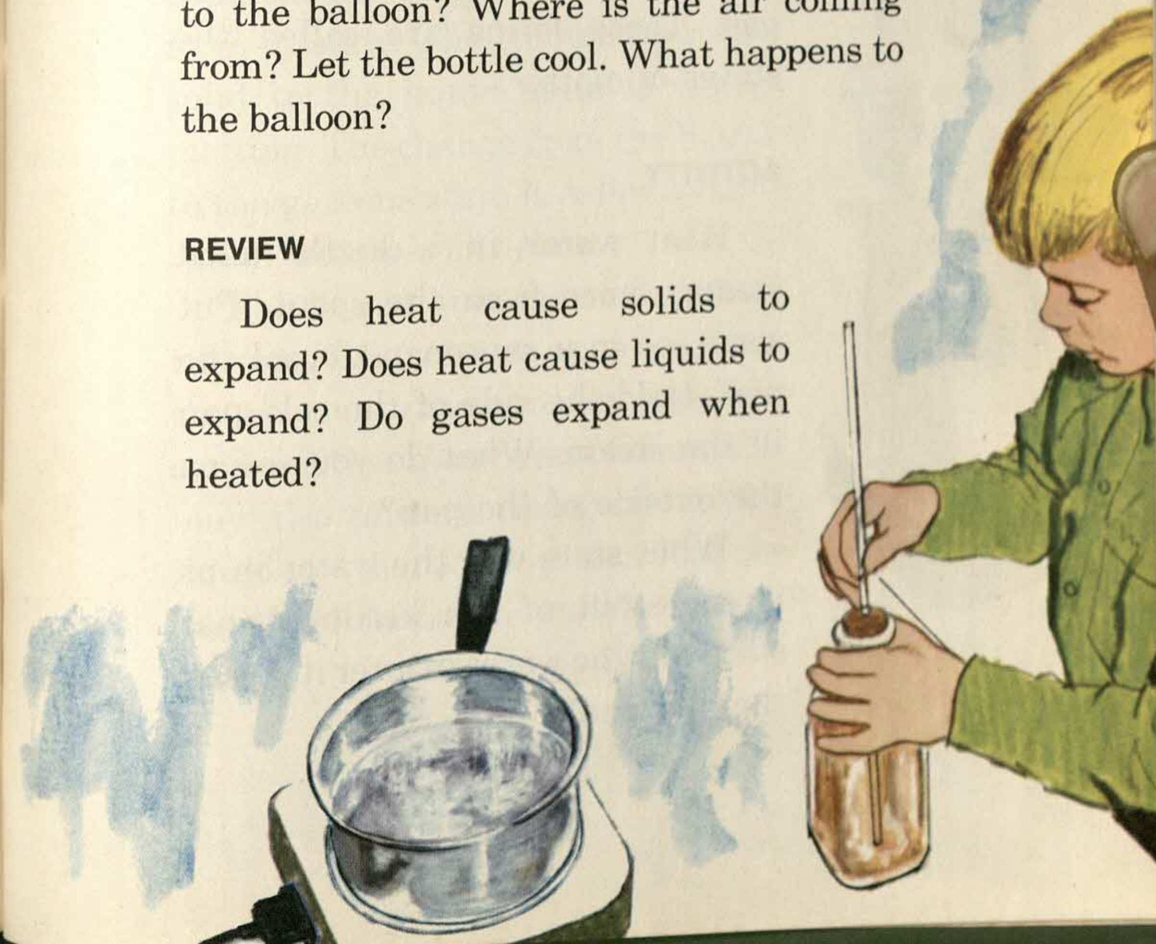
ACTIVITY

Fill a milk bottle with colored water. Fit a cork with an 18-inch glass tube. Cork the bottle with it, as shown in the picture. Place the bottle in a small pan of water and heat it. What happens to the water in the glass tube? Remove the bottle from the pan. Use a potholder to protect your hands. Let the bottle cool. What happens to the water in the glass tube?

Fit a balloon over the neck of an empty pop bottle. Heat the bottle. What happens to the balloon? Where is the air coming from? Let the bottle cool. What happens to the balloon?

REVIEW

Does heat cause solids to expand? Does heat cause liquids to expand? Do gases expand when heated?



Changes of State

Put an ice cube into a pan and heat the pan. What happens to the ice cube? In what form was the water when it was ice? In what form is it after it melts? Continue heating the water until it boils. What happens if more heat is added? What name is given to this form of water?

You have seen water in three different forms: solid, liquid, and gas. These forms are called the states of matter.

ACTIVITY

Heat water in a kettle until steam comes from the spout. Put some ice in a saucepan to cool the pan. Hold the side of the cold pan in the steam. What do you see on the outside of the pan?

What state was the water in as it came out of the kettle? What state was the water in after it struck the cold pan?

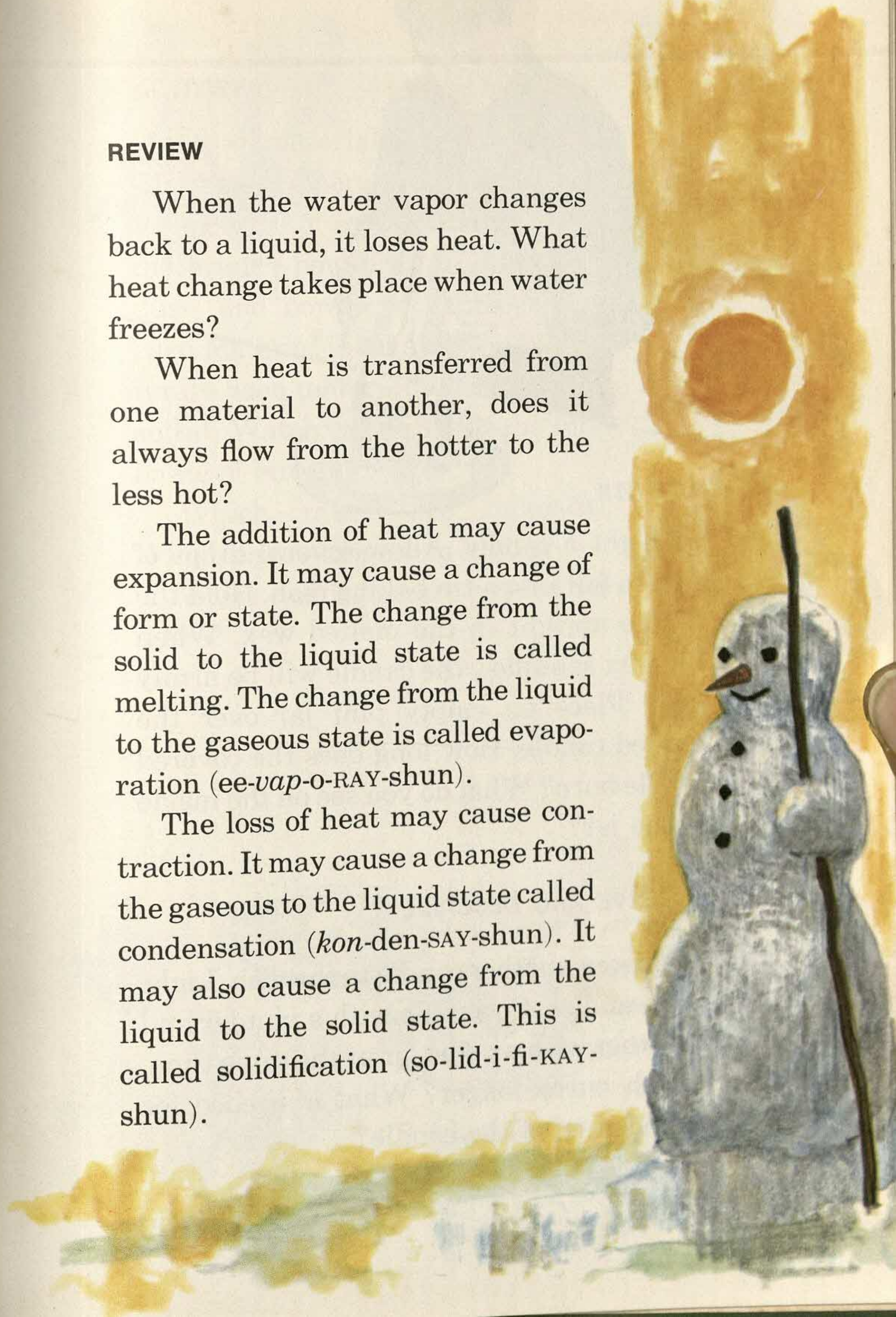
REVIEW

When the water vapor changes back to a liquid, it loses heat. What heat change takes place when water freezes?

When heat is transferred from one material to another, does it always flow from the hotter to the less hot?

The addition of heat may cause expansion. It may cause a change of form or state. The change from the solid to the liquid state is called melting. The change from the liquid to the gaseous state is called evaporation (ee-*vap*-o-RAY-shun).

The loss of heat may cause contraction. It may cause a change from the gaseous to the liquid state called condensation (*kon*-den-SAY-shun). It may also cause a change from the liquid to the solid state. This is called solidification (so-lid-i-fi-KAY-shun).



ACTIVITY

Light a candle. Allow several drops of wax to fall into a tin baking dish. Hold the candle upright in the melted wax. When the wax solidifies, the candle will be firmly held. Place an empty pint jar over the lighted candle. How long does the covered candle burn? What do you see on the inside of the jar?

OBSERVE AND DESCRIBE

Fasten another candle to the dish. Light both candles. Cover one with a pint jar and the other with a quart jar at the same time. Which burns longer? What is needed for the burning of the candle?

ACTIVITY

Do all materials begin to burn at the same temperature? Take a level teaspoonful of each of the following materials: powdered sulfur, sawdust, and powdered charcoal. Put each material in an aluminum dish. Ignite each material with a lighted splint. Watch carefully for the blue flame of burning sulfur.

Which takes fire quickest? Which takes longest to ignite?

What conditions are needed for a fire?

Heat Movement in Solids, Liquids, and Gases

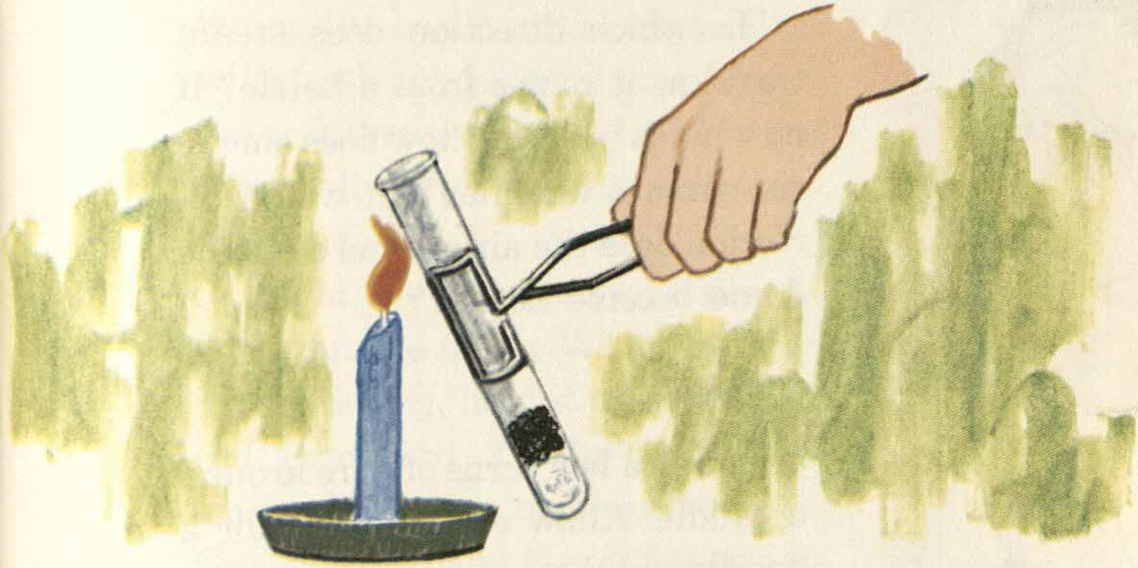
Take a solid brass curtain rod. Attach tacks to it with a few drops of candle wax. Space the tacks about two inches apart. Hold one end of the rod in a flame. In what order do the tacks drop? What does this activity show about heat? This method of heat travel in solids is called conduction (kon-DUK-shun).

Do all solids conduct at the same rate? Get four rods of the same size, but of different materials. Iron, glass, wood, and brass are good samples.

Punch four holes in the lid of a coffee can. The holes should be big enough to hold the four rods. Pour an inch of water into the can and cover it. Push the four rods through the holes into the water to the same depth. Attach a tack with wax to the upper end of each rod.

Heat the water in the can. In what order do the tacks drop? Which material do you think is the best conductor of heat?

Not all materials conduct heat at the same rate. Materials that are poor conductors of heat are called heat insulators (IN-su-*lay*-terz).



OBSERVE

Is water a good conductor of heat? Drop a piece of ice into a test tube and wedge it in with a piece of steel wool. Fill the test tube with water. Heat the test tube at the top. When the water at the top is boiling, observe the ice. What do you conclude about water as a conductor of heat?

Is air a good heat conductor? Light a candle. Hold a thermometer about ten inches above the flame. What do you observe? Now hold the thermometer the same distance from the side of the flame. What do you observe this time?

In which direction does steam travel as it comes from a kettle? If no wind is blowing, how does smoke rise from a chimney? In which direction does the air around a candle flame become hottest?

ACTIVITY

Wrap a few turns of wire around a candle. Allow enough wire for a handle, so that you can lower the candle into a milk bottle. Light the candle. Lower it into the bottle. What happens to the flame? Why?

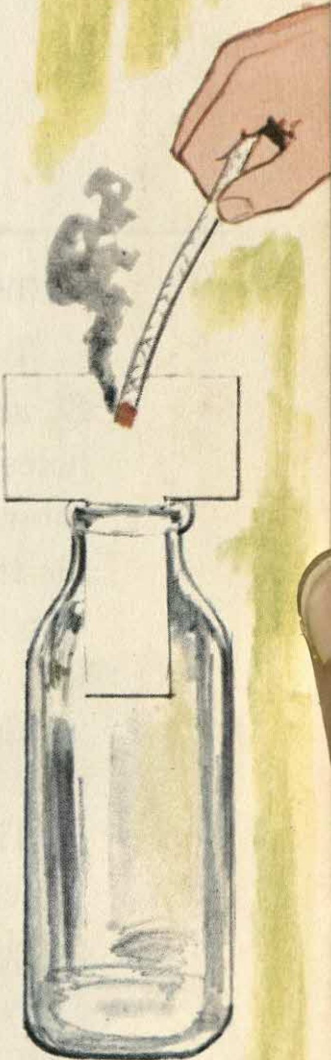
The air in the bottle is heated and rises. It blocks the mouth of the bottle, preventing fresh air from entering. How can this be corrected?

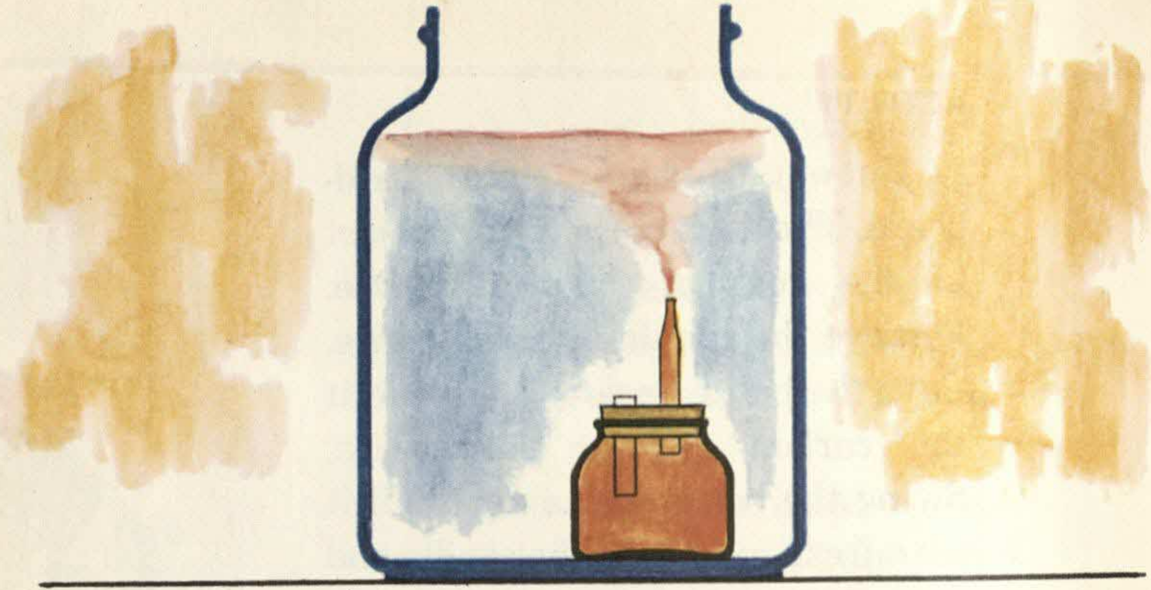
ACTIVITY

Cut out a T-shaped piece of cardboard. The stem of the T should just fit the neck of the milk bottle. Remove the candle from the bottle. Turn the bottle upside down so that the carbon dioxide can escape. Swing the bottle in the air to fill it with fresh air. Light the candle and lower it into the bottle. Quickly put the cardboard T in place. Observe the candle.

Light one end of a piece of rope. Blow out the flame. While the rope is smoldering, hold it to one side of the cardboard T. How does the smoke drift? Now try the other side. Can you explain the difference in the direction of the smoke?

Is hot air carrying the smoke upward on one side of the T? What is happening on the other side? Which is heavier, hot air or cold? The upward and downward drafts of air are called convection (kun-VEK-shun) currents. Heat is sometimes transferred by convection currents.





ACTIVITY

To show convection currents in water, fit an ink bottle with a cork. Make two holes in the cork to hold two pieces of glass tubing. You may use a medicine dropper for the pointed tube. Fill the bottle with very hot water, colored deeply with ink or food coloring. Fill a large jar with cold water. Lower the ink bottle into the jar of cold water. Observe what happens.

The smoke showed the direction of the air currents in the last activity. What is carried about by the currents in the jar? How do you know that the cold water is falling? What name is given to these currents? How is heat transferred from the hot to the cooler regions?

ACTIVITY

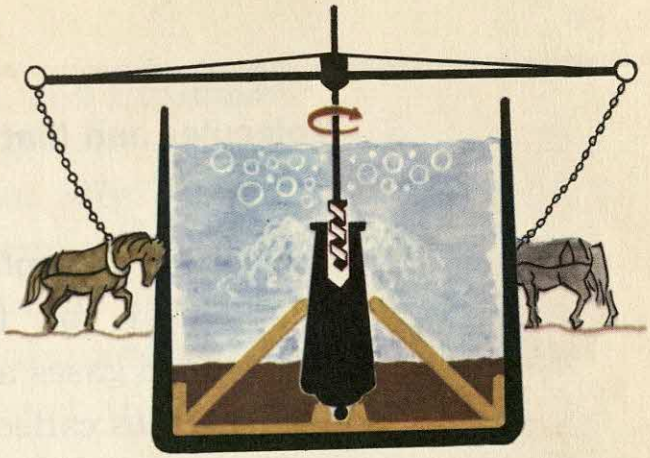
Move your hand around an unlighted electric bulb. Do you feel any heat from it at all? Turn on the electricity and repeat the movement of your hand. In which positions do you feel the heat from the bulb? Where must your hand be to receive the heat from the bulb by convection? How is heat traveling from the bulb?

Heat travels in all directions from any hot object. This kind of heat transfer is called radiation (*ray*-dee-AY-shun). Heat travels through space by radiation. Radiation does not require solids as conduction does. It does not require fluids as convection does.

Democritus, a Greek who lived in the fourth century B.C., had a theory. He thought that heat was tiny particles that flowed from some objects with such speed that they could go into water and solid materials. For many centuries, heat was considered to be tiny particles.

Then some unknown thinker got the idea that heat was a kind of fluid. He called it "caloric." It was present in every material, he said. Some materials had more of it and some had less. You could squeeze caloric out of materials by holding them over flames. This explanation of heat was accepted for several more centuries.

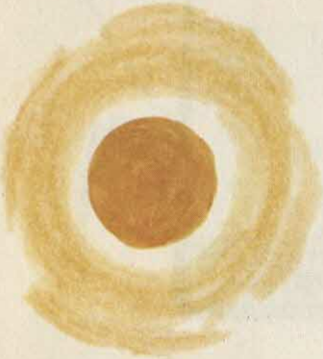
Benjamin Thompson, who later became Count Rumford, did not believe in caloric. He suspected that heat was not a form of material. Materials had weight. He tried many experiments. He made many measurements. He could find no evidence that heat had weight.



In 1789, Thompson was supervising the boring of a cannon when an idea came to him. He placed the cannon in a tank of water. Then he bored a hole in it with a blunt steel drill. The drill was turned by a team of horses.

Thompson took the temperature of the water from time to time during the drilling process. After two and a half hours, the water actually boiled. Where had the heat come from? Nothing had entered the water.

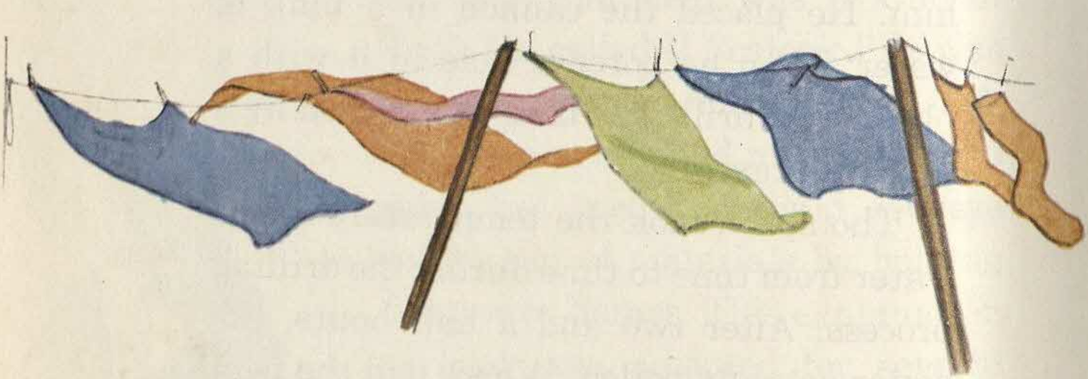
The only thing that was different from before the experiment to its ending was that there had been movement. The movement of the tool, boring its way into the cannon, was responsible for the heat, said Thompson. So he concluded that heat was not a form of material, but it seemed to be related to motion. Then what is heat?



Molecules and Materials

In order to explain heat, it will help you if you think of solids, liquids, and gases as being made of tiny particles called molecules.

These particles, or molecules, are much too tiny to see. They are moving all of the time.



What happens to the water vapor that rises from clothes drying in the sunshine?

Why do you smell the gas in the living room, if someone leaves the kitchen burner on and unlighted?

Molecules, Heat, and Expansion

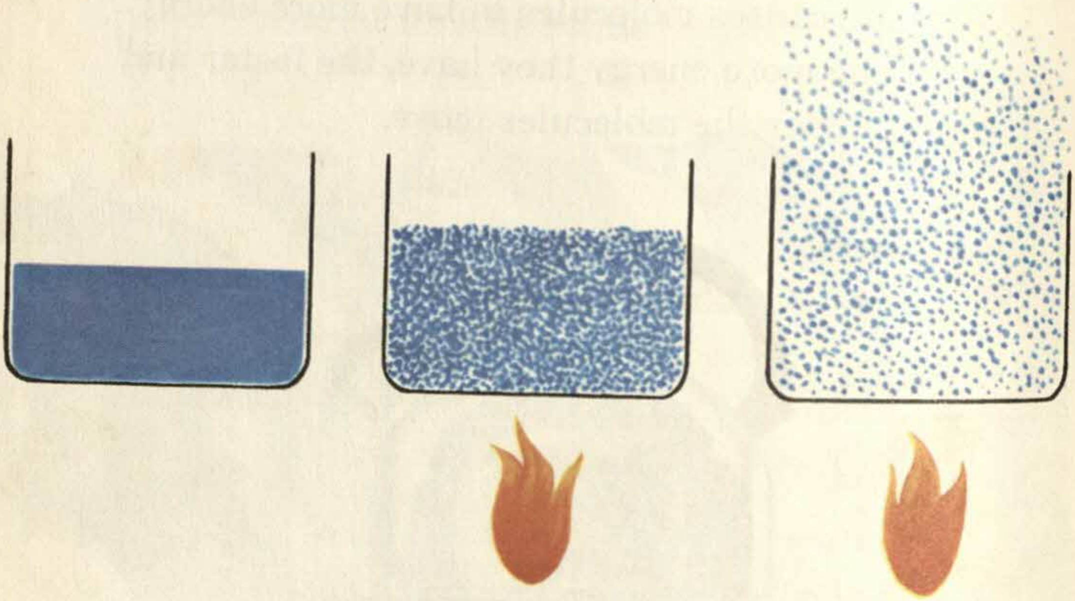
How does heat affect the energy of molecules? Take a cup of hot tea and a cup of cold tea. Drop a level teaspoonful of sugar into each, but do not stir it. Wait one minute, then taste both cups of tea. Which tastes sweeter?

Heat is a form of energy. Perhaps heating causes molecules to have more energy. The more energy they have, the faster and further the molecules move.

Benjamin Thompson felt that heat was related to motion, but he could not explain how. He did not know about molecules. There is a relationship between heat energy and molecular motion.

What change in the movement of molecules takes place during melting?

Molecules of materials in the liquid state move past each other freely. What happens if the liquid is heated to the boiling temperature? If enough heat is added to set the molecules free of the liquid, what happens?

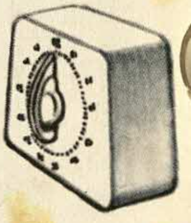


How does the relationship between heat and molecular motion explain a change from solid to liquid? from liquid to gas?

Is temperature the same as heat? Do the following activity and try to decide for yourself.

Heat and Temperature

Put a quart of cold tap water in a pan. Place a kitchen thermometer in the water and wait five minutes. What is the temperature? Now place the pan of water with the thermometer on a hot plate or stove. Turn on the heat and note the time. Heat the water until the temperature is 150°. See how long this takes.



Empty the pan and repeat the activity. But this time use only one pint of cold tap water. Be sure that you use the same setting for the heat as before. Note the time it takes to heat the pint of water to 150°.

How long did it take to raise the temperature of the quart of water to 150°? How long did it take to raise the temperature of the pint of water to 150°? Which required more heat?

Can you answer the question now? Is temperature the same as heat?

THINK

If you were given an unknown powder, what would you do to find out its properties?

Scientists use many ways to separate dissolved and undissolved substances in liquids. Name as many ways that you can to do this.

PROJECTS

Collect some solids and liquids found around your home. Try to learn as much as you can about their properties.

Test a jar of water with different indicators. Record the results of your tests. Put some dry ice in the jar. (Be careful not to touch the dry ice with your hands.) Wait until it disappears completely, and then test the water again with the same indicators. Are there any changes in reaction?

Acknowledgment

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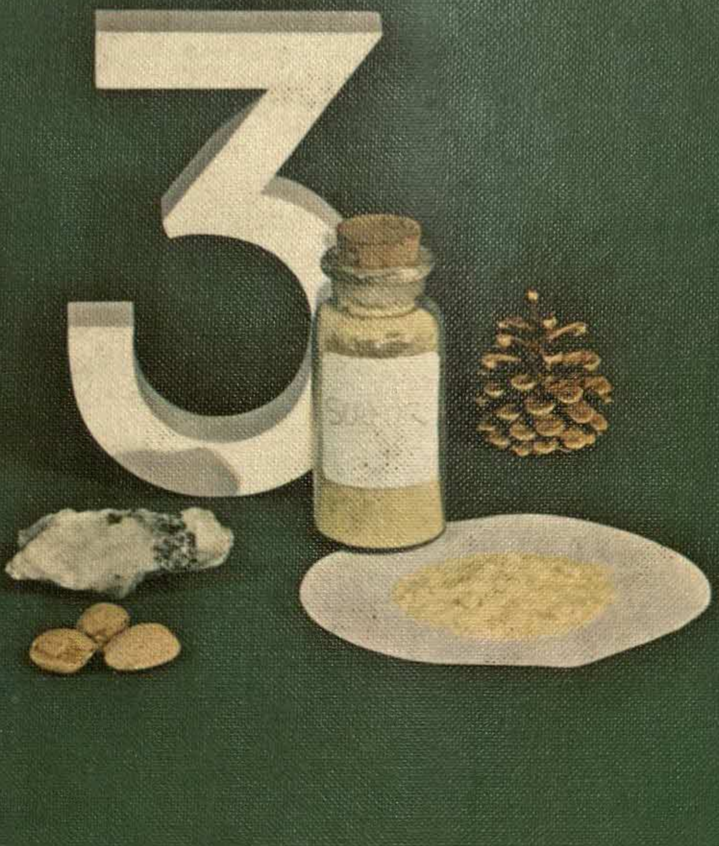
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